RADIOLOGICAL DEFENSE

Vol. II

The Principles of
Military Defense against Atomic Weapons

Armed Forces Special Weapons Project

November 1951

While the atomic bomb is admittedly a weapon of great power, it is not to be regarded as an absolute weapon—that is to say, it is not a weapon against which there is no defense. Throughout history, the introduction of every new weapon has been followed by the development of defensive measures which have lessened its effectiveness. However, the development of suitable defensive measures against atomic weapons requires an understanding of the characteristics and effects of these weapons under various circumstances. Unfortunately, many misleading and exaggerated reports of the consequences of such weapons have received wide publicity, and these have made more difficult the task of those responsible for the planning of atomic defense.

In the event of a future war, a commander must consider the enemy's use of atomic weapons in his own strategic plans or tactical decisions. He also must know what precautionary measures will minimize the hazard to his own forces when taking advantage of the situation created by an atomic attack on the enemy. Further, in an emergency, each member of the Armed Services may have to act, possibly without warning, for his own protection. The purpose of the present volume, "Military Defense against Atomic Weapons," is to provide, in its true perspective, the essential background information which will make possible intelligent planning in advance and appropriate action in an emergency.

The first half of the book deals with the characteristics of atomic weapons, and with their effects on structures, equipment, and personnel, as far as they are of military significance. The final half considers the steps that may be taken to minimize these effects and to control their consequences. Since a relatively small number of atomic bombs has been detonated, so far, and there are many different conditions under which the weapon might be used, the information is necessarily incomplete. The conclusions drawn are thus the best that are possible in the circumstances, but are liable to change and improvement as more facts become available.

It should be emphasized that the radiological aspect of atomic defense is not necessarily the most important aspect. In the case of an air burst, for example, most casualties will be due to mechanical injuries and burns. However, radiation does present a novel feature of warfare resulting from the introduction of atomic weapons. It is for this reason that the subject of radiological defense is treated at some length.

It has been considered desirable in this volume to present the over-all picture of atomic defense as it applies to all three Services in a variety of circumstances. These may range from a situation in which there is direct contact with the enemy in the field or at sea, to that of an industrial type military installation adjacent to an urban area in the continental United States. While the individual problems in the different situations will inevitably be different, certain general principles will hold in every case. It is these fundamental principles which are covered herein.

Radiological defense, like other aspects of defense, will involve a number of specialized operations, such as use of instruments, survey of areas and equipment contaminated with radioactive material, and the decontamination of such areas and equipment. It is not the intent of this book to discuss these operations in detail, although their main principles and the parts they play in the general defense program are outlined. The operations will be performed by personnel trained especially for the various purposes, and for whom the individual Services are providing de-

tailed training and specialized technical manuals suited to their individual requirements.

This volume is the second of a series of Radiological Defense Manuals issued by the Armed Forces Special Weapons Project for indoctrination and training use in the Armed Services. Due to the additional time required to assemble the information required for this book, however, Volumes III and IV were completed and published prior to this present work. These other volumes deal with the medical aspects of atomic warfare and with radiac instruments, respectively. The original member of the series (Volume I) deals principally with nuclear physics. As has been indicated in the foregoing paragraphs, Volume II is intended to be the planning and operational member of this series.

The original drafts of the material for this volume were prepared at the Naval Radiological Defense Laboratory, San Francisco, partly from contributions of its staff and partly from material supplied by other representatives of the Armed Services who collaborated in this work. It is regretted that it is not feasible to list the names of the many individuals, both uniformed and civilian, who have assisted in the assembly and review of the contents of this book. Their efforts are sincerely appreciated. It is also desired to acknowledge the valuable assistance rendered by the Atomic Energy Commission in making available Dr. Samuel Glasstone, who acted as Executive Editor in the final rewriting and integration of the manuscript.

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Chapter 1

HISTORICAL EXPERIENCE

THE ATOMIC BOMB IN WARFARE

The Hiroshima Bomb

1.01. The first use of the atomic bomb in warfare occurred on 6 August 1945, at Hiroshima, in Japan. This port city, which at the time had an estimated population of over 300,000 persons, military and civilian, lies on a flat, fan-shaped delta of the Ota River. Soon after 0800 on the aforementioned day, three United States aircraft appeared over the city, but little attention was paid to them. Half an hour before, the "all clear" had been sounded from an earlier warning and, consequently, all but a few persons had left the air-raid shelters and were on their way to work. It is estimated that some three-quarters of the population were then in the congested 4-square-mile center of the city, many of them still in the streets.

1.02. The bomb was dropped over the center of Hiroshima and exploded at a height of about 2,000 feet above the ground. This altitude was chosen deliberately, as will be seen later, in order to produce the maximum amount of damage to structures in the city. The explosion was accompanied by a brilliant flash of light and an intense wave of heat, that was felt nearly 4 miles away. Immediately thereafter came a violent blast of air the force of which destroyed, or rendered useless, buildings up to a distance of nearly 2 miles from the center of the explosion (figs. 1.02 a and b). As far away as 8 miles, glass was broken and plaster damaged. At the same time all public utilities—water, electricity, gas, transportation, and telephone services—were disrupted.

1.03 Due to the breaking of gas lines, the overturning of stoves and furnaces, and for other reasons, fires soon broke out in various parts of the city. Buildings damaged by the blast were particularly vulnerable to the spread of fire, and within 20 minutes of the detonation of the atomic bomb more than 4 square miles of Hiroshima were a mass of flames. However, little or nothing could have been done to restrict the conflagration. It is true that the fire-fighting services and equipment in Hiroshima were poor by American standards, but it is very doubtful if much could have been achieved, in the circumstances, by more efficient fire departments. Nearly 70 percent of the city's fire-fighting equipment was destroyed and about 80 percent of the firemen on duty were immediate casualties. Even if the men and machines had survived the blast, many places were inaccessible because of the streets being blocked with debris. Further, the damage to water pipes made the water pressure so low that it would have been of little use for controlling fires.

1.04. The atomic explosion over Hiroshima resulted in the death of about 70,000 persons and the injury of an almost equal number. Thus, nearly half of the city's population became immediate casualties. Many people became sick in subsequent weeks due to overexposure to the nuclear radiation that is a characteristic of the atomic bomb. The high casualty rate in Hiroshima was undoubtedly due to the fact, mentioned above, that at the time of the explosion a considerable proportion of the population was concentrated near the center of the city, with an unusually large number in the streets.

1.05. The three planes, which appeared over the city so soon after an "all clear" had been given, were not taken seriously. It was thought that they were observation planes, and even if they had been bombers, their bomb load was evidently not considered sufficient to merit a further disruption of the city's daily routine. From the standpoint of defense against the atomic bomb, the important lesson is that no enemy plane, whether it comes singly or in a group, can be disregarded. Had the inhabitants of Hiroshima remained in their shelters, the number of casualties would have been greatly decreased. The material destruction would presumably have been the same, but care of the injured and

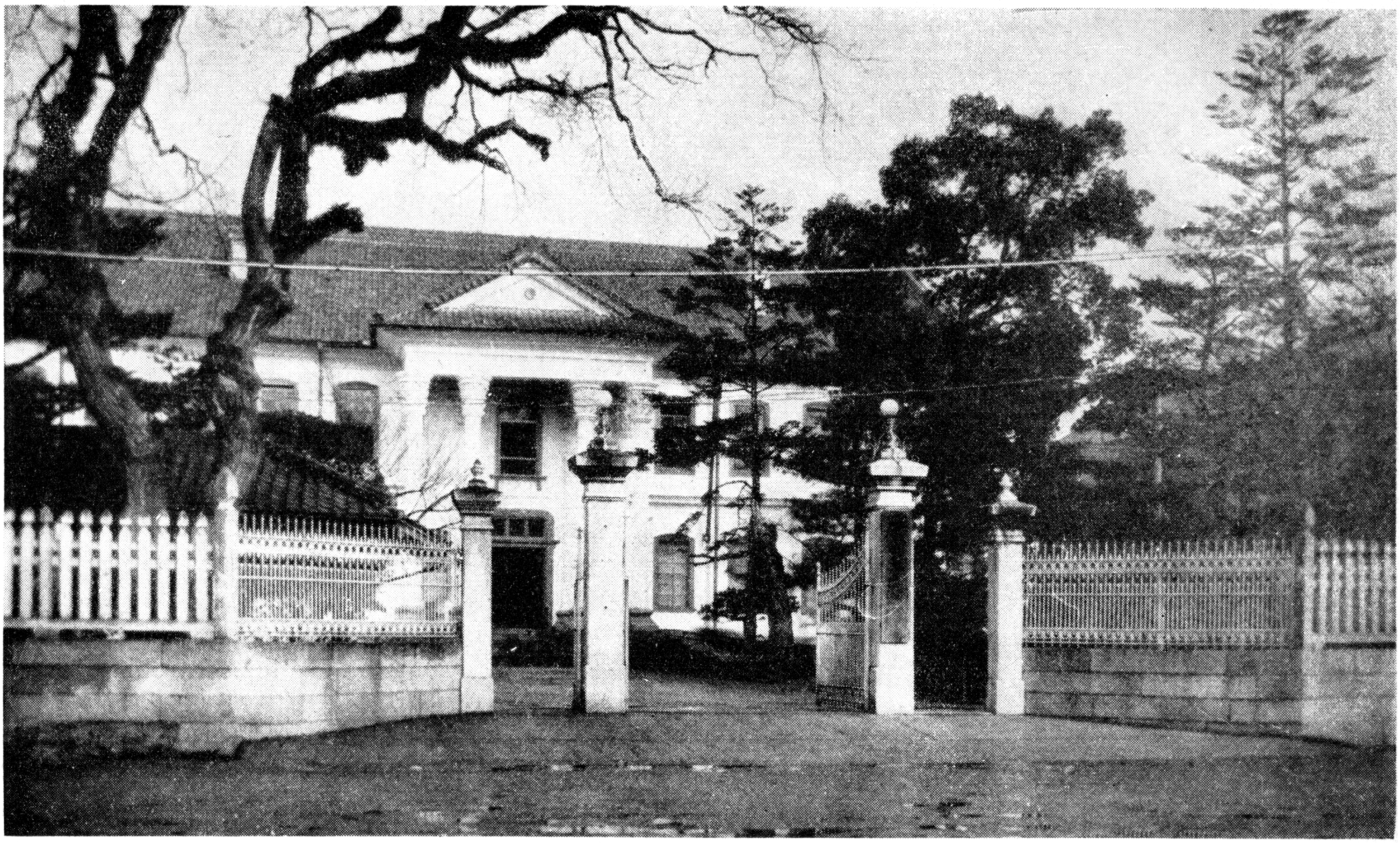


Figure 1.02a. The Hiroshima Prefecture (approximately 1,000 yards from ground zero) before the atomic explosion.

rehabilitation and repair of the city after the explosion would have been greatly facilitated.

The Nagasaki Bomb

1.06. Three days after the attack on Hiroshima, at 1102 on 9 August 1945, an atomic bomb was exploded over the industrial seaport of Nagasaki, with a population of 230,000. The city lies on a small plain which extends up two relatively narrow valleys, between hills rising some 1,000 feet above sea level. The heavily industrialized part was located in the larger of the two valleys, and it was approximately 2,000 feet above this area that the bomb was exploded (fig. 1.06). As a result, the huge Mitsubishi Ordnance Plants, which were in the Arakami valley, were destroyed, but the harbor and commercial areas, and much of the residential area, escaped serious damage. One of the factors responsible was the hilly nature of the terrain. Many houses, built in ravines, were sheltered by the hills, and thus protected from the blast.

1.07. The fires which followed the blast spread more slowly and covered a smaller area (about 1.8 square miles) than at Hiroshima. There were two reasons for this. First, the factory area at Nagasaki, over which the bomb was dropped, contained less combustible material than the business and residential parts of Hiroshima. And second, the wind, which developed some time after the conflagration had become well established, tended to carry the fire up the valley in a direction where there was nothing to burn. Had the wind been in the opposite direction, toward the shore instead of away from it, the consequences might have been quite different.

1.08. Because of the tremendous psychological shock and the disruption of communications following the bombing of Hiroshima, reliable news was not available in other parts of Japan. Consequently, Nagasaki was little better prepared for the atomic attack, with the result that about 36,000 people were killed and 40,000 injured. The city had been on a warning alert for more than 2 hours before the bomb fell, but no raid alarm had been given and only a few hundred persons were in shelters. However, because of the time of day, and the different circumstances, the proportion of the population in the streets in Nagasaki was not so large as at Hiroshima. This may account, in part, for the smaller number of casualties.

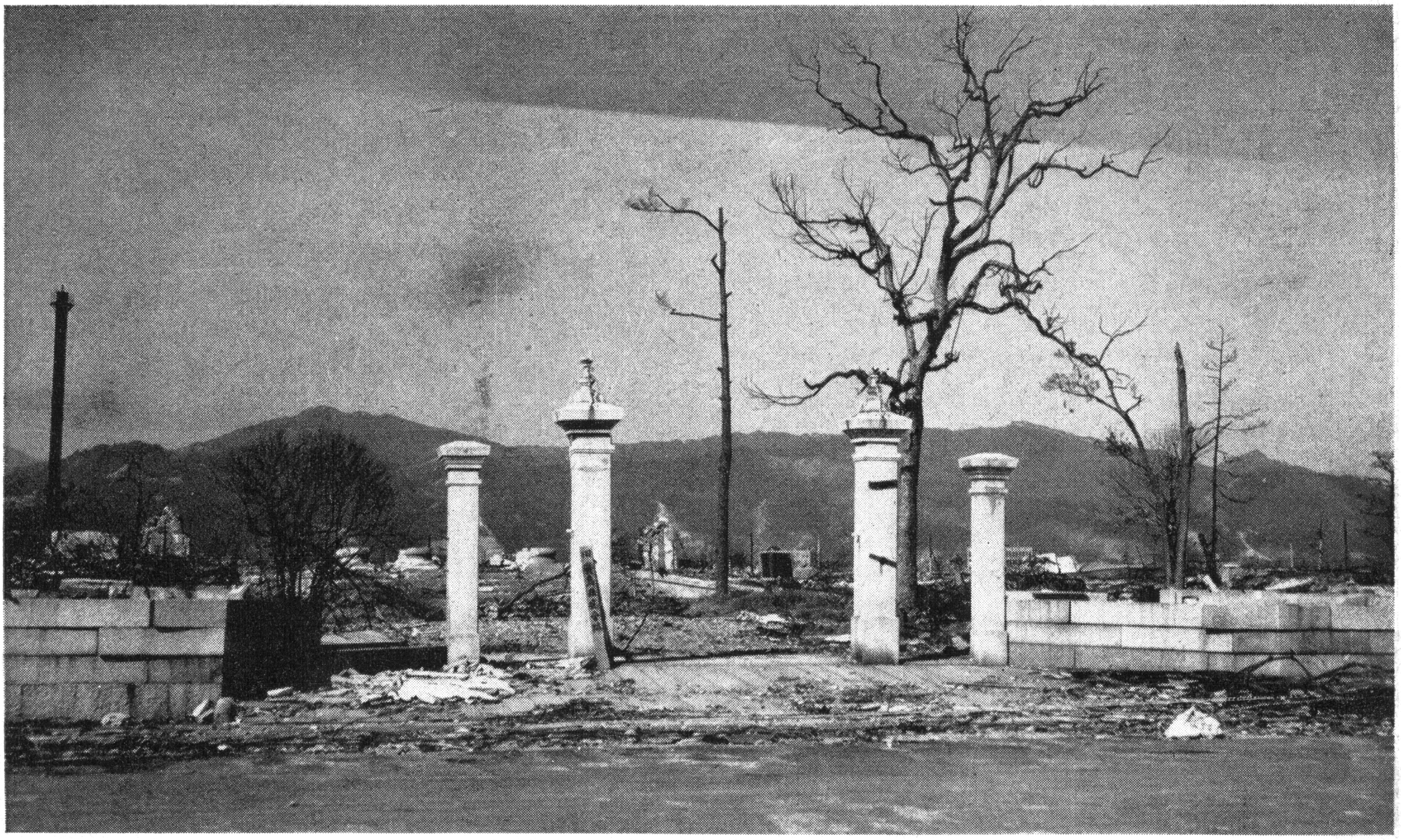


Figure 1.02b. The Hiroshima Prefecture after the atomic explosion.

1.09. Since a large number of the inhabitants as well as considerable residential areas of the city survived the explosion, rescue efforts at Nagasaki were soon organized. The water supply was partially restored by the second day after the dropping of the bomb, and some electric power was available at the end of the same day. On the following day a few streetcars and railway trains were running again.

Studies of Damage and Casualties

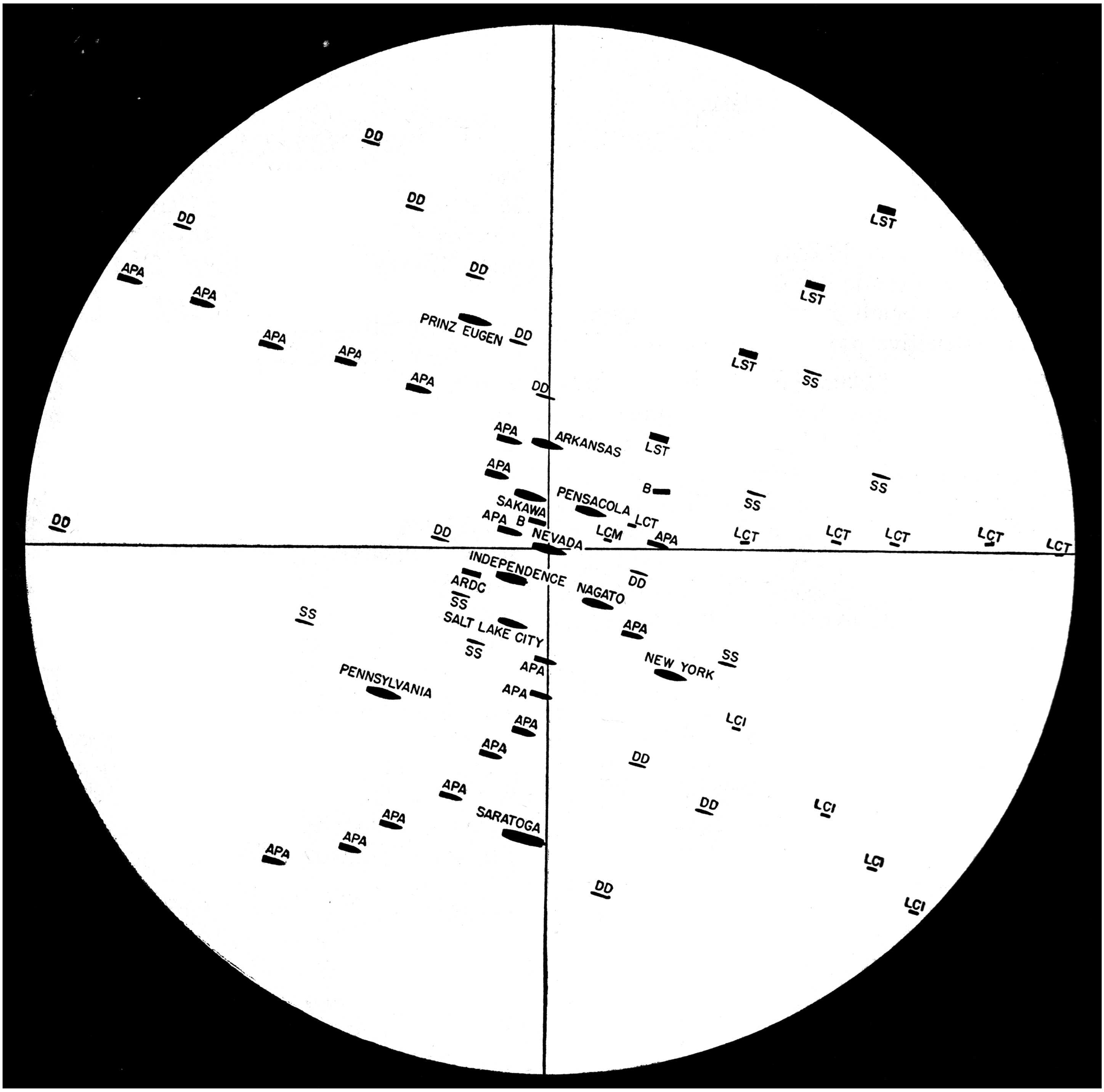
1.10. The damage and casualties due to the atomic bombs at Hiroshima and Nagasaki are summarized in table 1.10. For purposes of comparison the corresponding figures are given for the destructive air raid on Tokyo on 10 March 1945, made largely with incendiary bombs, and the average of 93 air attacks on Japanese cities with similar weapons. The outstanding feature of the atomic bomb is seen to be the high casualty rate per square mile destroyed. Thus, atomic bombs have a greater "saturation" character than bombs of the more conventional type.

1.11. Soon after the cessation of World War II, teams of observers from the United States and from Great Britain went to Japan to make detailed studies of the effects of the atomic bombings on both structures and personnel. The main purpose of the studies was to obtain information useful in the development of defense measures. Comprehensive reports have been issued both by the United States Strategic Bombing Survey and the British Mission to Japan.

Table 1.10. Comparison of Casualties from Atomic and Conventional Bombs[1]

	Hiroshima Atomic Bomb	Nagasaki Atomic Bomb	Tokyo 1,667 tons Incendiary and TNT	Average of 93 Attacks 1,129 tons Incendiary and TNT per attack
Population per square mile . .	35,000	65,000	130,000	—
Square miles destroyed	4.7	1.8	15.8	1.8
Killed and missing	70,000	36,000	83,000	1,850
Injured	70,000	40,000	102,000	1,830
Mortality per square mile destroyed .	15,000	20,000	5,200	1,000
Casualties per square mile destroyed .	30,000	42,000	11,800	2,000

[1] "The Effects of Atomic Weapons," U.S. Government Printing Office, Washington, D.C.



DD	DESTROYER	LST	LANDING SHIP TANK	LCM	LANDING CRAFT MECHANIZED
SS	SUBMARINE	LCI	LANDING CRAFT INFANTRY	ARDC	FLOATING DRYDOCK
APA	ATTACK TRANSPORT	LCT	LANDING CRAFT TANK	B	BARGE

Figure 1.16. Drawing of the Bikini Test Able target array as the bombardier might have seen it. In order to give accurate instrumentation of graded damage the concentration of ships was much higher than would normally be found in a tactical situation.

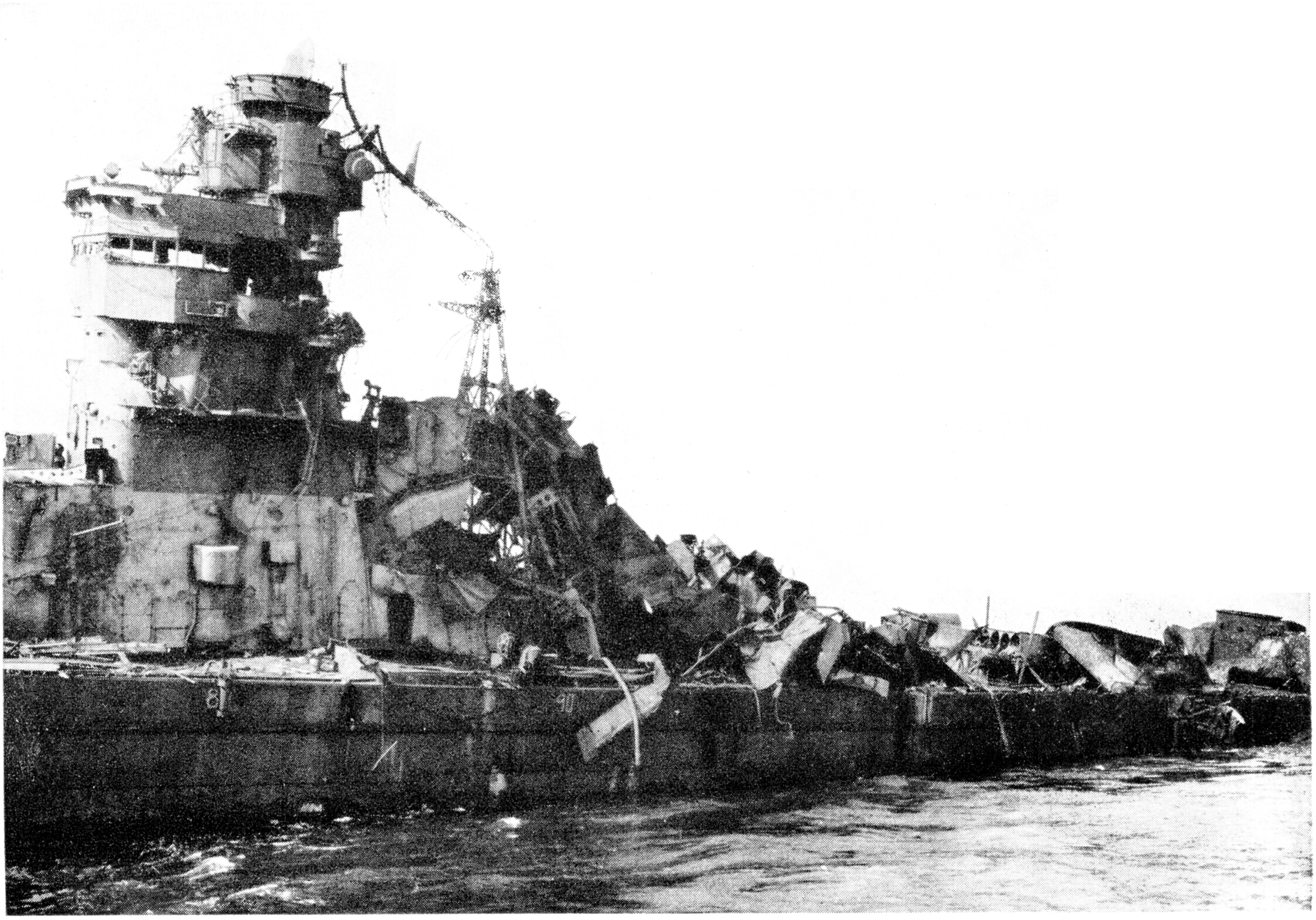


Figure 1.19a. The Japanese cruiser SAKAWA after Test Able at Bikini.

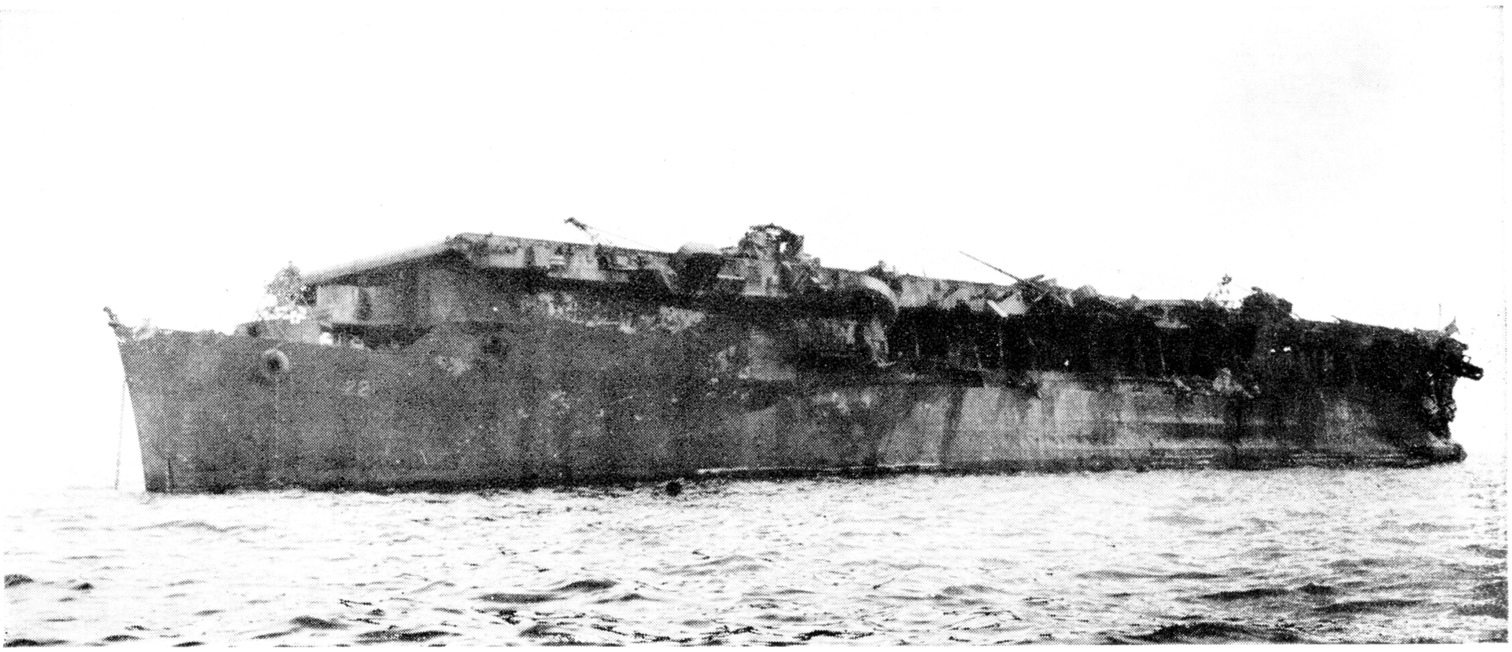


Figure 1.19b. The light aircraft carrier INDEPENDENCE after Test Able at Bikini.

Table 6.27. Limiting Damage Ranges from Ground Zero for Thermal Radiation Effects in an Air Burst of a Nominal Bomb

Material	Effect	Heat energy required (cal./sq. cm.)	Limiting distance: Very clear day (yards)	Limiting distance: Hazy day (yards)
Cotton shirting, khaki, 3.75 oz.	Scorches	6	2800	1650
	Burns	15	1750	1150
Cotton twill, khaki, 8.2 oz. (as used in summer uniforms).	Scorches	9	2300	1400
	Burns	15	1750	1150
Cotton, herringbone twill, green, 9 oz (as used in combat uniforms).	Scorches	3	3900	2000
	Burns	17	1600	1050
Cotton duck, white, 7 oz.	Scorches	34	1150	800
	Burns	42	1050	650
Worsted, tropical khaki, 10 oz.	Nap scorches	9	2300	1400
	Burns	18	1550	1000
Wool gabardine, khaki, 14 oz.	Scorches	6	2800	1650
	Burns	23	1400	900
Wool gabardine, USAF blue No. 84, 12 oz.	Scorches	3	3900	2000
	Burns	9	2300	1400
Wool flannel, Navy blue, 11 oz (as used in undress jumpers).	Scorches	3	3900	2000
	Burns	9	2300	1400
Wool melton, Navy blue, 16 oz (as used in dress blues).	Scorches	3	3900	2000
	Burns	11	2100	1300
Wool serge, Navy blue, 14 oz.	Scorches	3	3900	2000
	Burns	9	2300	1400
Wool serge, Army olive drab, 18 oz.	Scorches	4	3400	1900
	Burns	15	1750	1150
Wool serge, USMC, green, 12 oz.	Scorches	3	3900	2000
	Burns	19	1550	1000
Wool elastique, USMC green, 19 oz.	Scorches	4	3400	1900
	Burns	35	1150	800
Wool kersey, USMC green, 16 oz.	Scorches	3	3900	2000
	Burns	32	1200	800
Wool kersey, Navy blue (as used in overcoats).	Scorches	3	3900	2000
	Burns	43	1050	650
Nylon, olive drab, 5.3 oz (as used in flying clothes).	Scorches	4	3400	1900
	Melts	8	2450	1450
Nylon, blue, 5.3 oz (as used in flying clothes).	Scorches	2	4500	2400
	Melts	7	2600	1550
Paper (white).	Chars	8	2450	1450
	Burns	10	2200	1350
Paper (brown kraft).	Burns	5	3100	1700
Douglas fir.	Chars	8	2450	1450
	Burns	11	2100	1300
Douglas fir (stained dark).	Burns	3	3900	2000
Philippine mahogany.	Chars	7	2600	1550
	Burns	9	2300	1400
Rubber (synthetic)	Burns	8	2450	1450

Heavy rubber coatings will experience only a superficial scorching, but thin coatings and sponge rubber will be seriously charred. Plastics and plastic glues generally do not stand up well to thermal radiation. For example, plastic parts may burn or fuse when rubber parts are only scorched. Plastic surface coatings and paints will show scorching, blistering, and discoloring.

6.30. The dependence of the damage range on the energy release of the bomb can be estimated from figure 3.44, which was given in chapter 3. The curves are for three different values of the thermal energy received on an average clear day: 3 cal./sq. cm. (causes moderate skin burns, black paper burns); 9 cal./sq. cm. (causes third degree skin burns, white paper burns); and 14 cal./sq. cm. (khaki cotton cloth burns). As pointed out in paragraph 3.45 the total amount of matériel, etc., affected by thermal radiation does not increase as rapidly as the energy release of the bomb, due to the nature of the scaling laws involved.

Primary and Secondary Fires

6.31. Fires accompanying an atomic explosion may be distinguished as primary or secondary, according to their origin. Primary fires are those caused directly by the thermal radiation igniting paper, thin cloth, rags, wood, dry vegetation, etc. Secondary fires are due to other causes, for which the blast is mainly responsible, such as upset stoves and furnaces, broken gas and other fuel lines, electrical short circuits, and so on. The evidence from Hiroshima and Nagasaki indicated that the great majority of fires were secondary in nature.

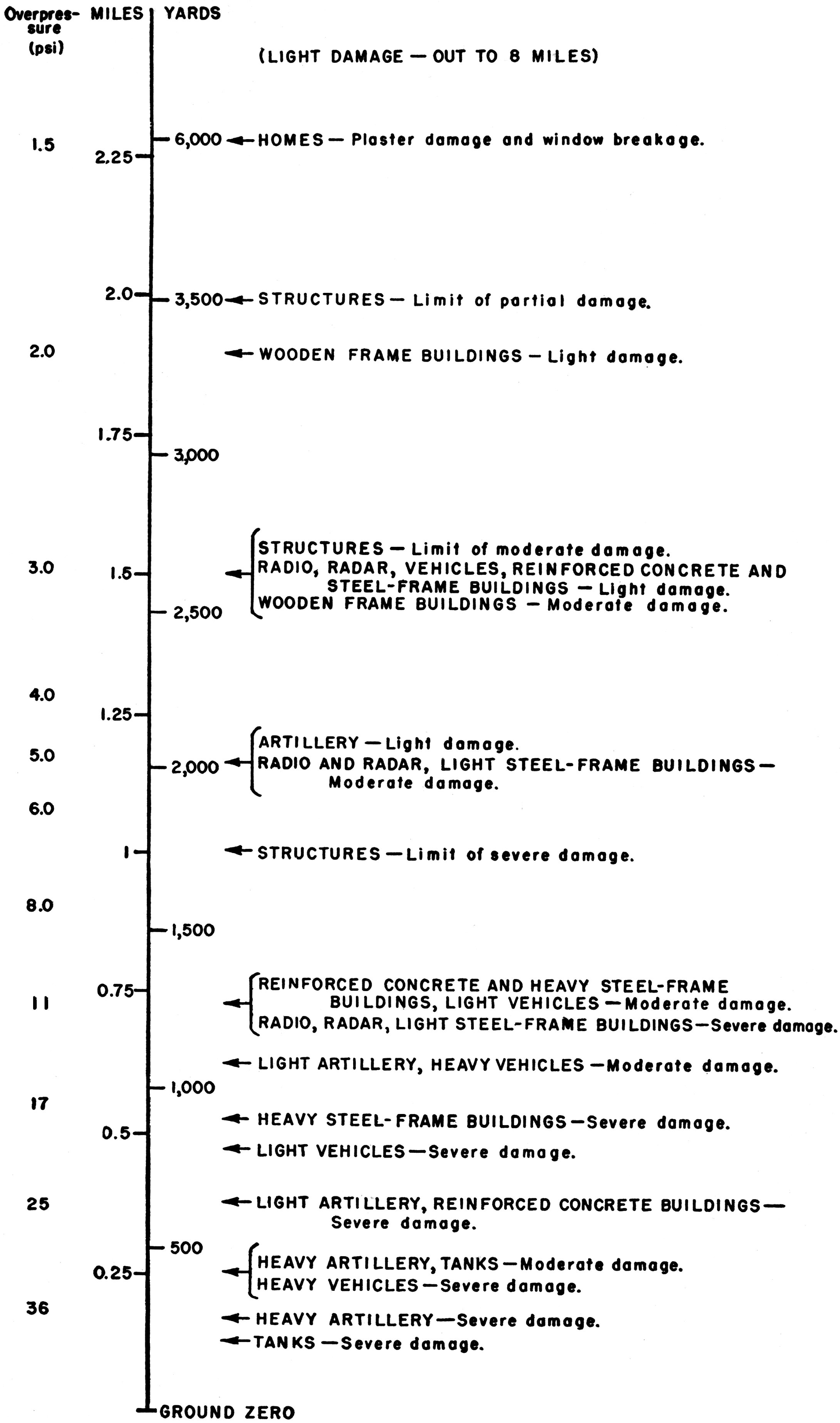


Table 6.59. Blast damage to various types of structures and matériel due to an air burst of a nominal atomic bomb at 2,000 feet altitude.

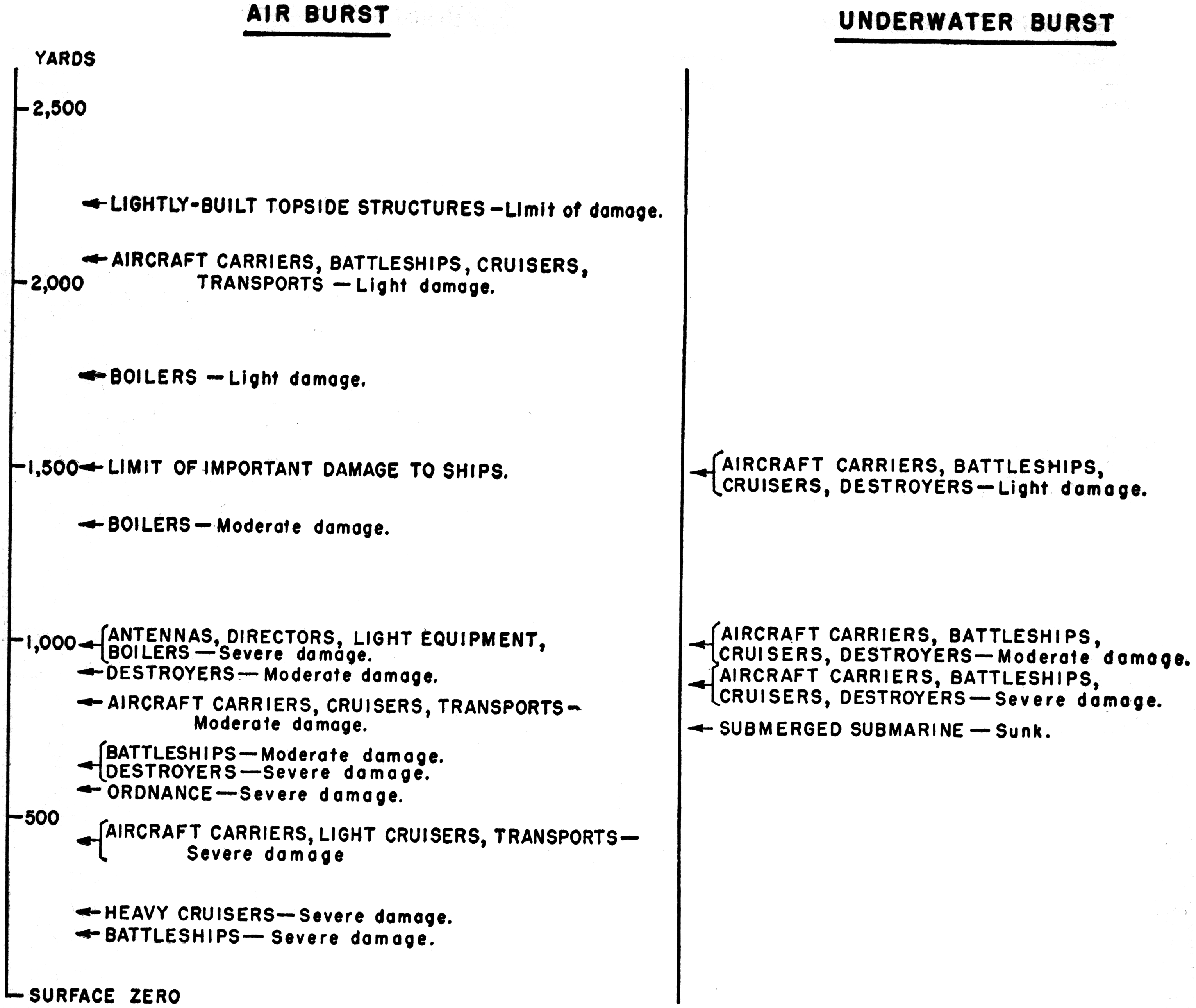


Table 6.92. Comparison of damage ranges to ships, due to air burst at 2,000 feet altitude and shallow underwater burst of a nominal atomic bomb.

flection of the blast wave from exposed surfaces into pockets or dead ends under overhanging structures, gun sponsons, etc.

6.97. On ships having large exposed deck areas, such as the well decks of older type cruisers, quarter-decks of battleships, cargo-handling decks of merchant-type vessels, the decks may be deformed as a result of blast pressure. The main strength water-tight hull will not be affected materially at ranges greater than 600 yards from the explosion of a nominal atomic bomb. This approximate limit applies to both air bursts and underwater bursts. For an underwater burst at ranges up to about 600 yards the underwater shock is sufficient to cause direct rupture of the hulls of most vessels, due to the effects previously discussed in paragraph 6.17. For an air burst, at distances closer than 600 yards the strength hull may be distorted above the water-line sufficiently to initiate cracks which will progress to below the water-line and permit extensive flooding. On light aircraft carriers, warping and buckling of flight decks probably will occur to about 700 yards (fig. 6.97). It is possible that the airplane elevators will be dislodged from their position, and it is still more likely that the distortion of the deck and resulting misalignment will render operation of the elevators impossible.

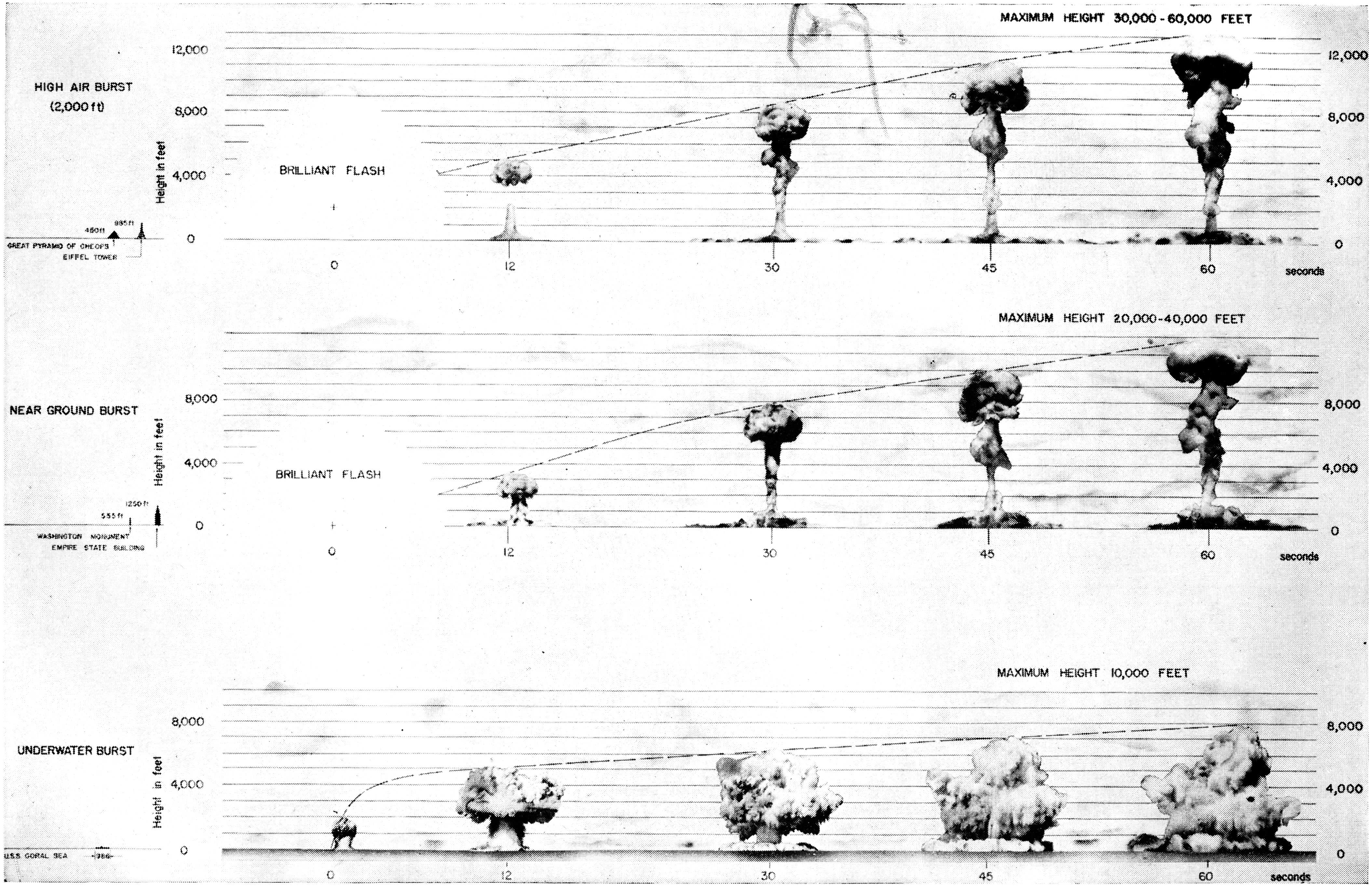


Figure 8.09. Composite photographs, on the same dimensional scale, showing development of an air burst, a surface burst, and an underwater burst.

Table 9.62. Allowable Stay Time in Area Contaminated by Fission Products from an Atomic Bomb Explosion

D/R = Allowable dose in roentgens divided by dose rate in roentgens per hour at time of entry	Time of entry in hours after the explosion																	
	0.1	0.2	0.5	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40
0.2	1–11	0–25	0–15	0–14	0–13	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12
0.3	9–40	1–00	0–22	0–22	0–20	0–19	0–19	0–19	0–19	0–18	0–18	0–18	0–18	0–18	0–18	0–18	0–18	0–18	0–18
0.4	312–24	2–22	0–42	0–31	0–27	0–26	0–26	0–25	0–25	0–25	0–25	0–25	0–25	0–24	0–24	0–24	0–24	0–24	0–24
0.5	∞	6–12	1–02	0–42	0–35	0–34	0–32	0–32	0–32	0–31	0–31	0–31	0–31	0–31	0–31	0–30	0–30	0–30	0–30
0.6		19–20	1–26	0–54	0–44	0–41	0–39	0–39	0–38	0–38	0–38	0–37	0–37	0–37	0–37	0–37	0–37	0–36	0–36
0.7		82–06	2–05	1–08	0–52	0–49	0–47	0–46	0–45	0–45	0–44	0–44	0–44	0–44	0–43	0–43	0–43	0–43	0–42
0.8		624–48	2–56	1–23	1–02	0–57	0–54	0–53	0–52	0–51	0–51	0–51	0–50	0–50	0–49	0–49	0–49	0–49	0–49
0.9		2000–00	4–09	1–42	1–12	1–05	1–02	1–00	0–59	0–58	0–58	0–57	0–57	0–57	0–56	0–55	0–55	0–55	0–55
1.0		∞	5–56	2–03	1–23	1–14	1–10	1–08	1–06	1–05	1–05	1–04	1–04	1–03	1–02	1–02	1–02	1–01	1–01
1.25			15–30	3–13	1–54	1–38	1–31	1–28	1–25	1–24	1–23	1–22	1–21	1–20	1–19	1–18	1–17	1–17	1–16
1.5			48–20	4–57	2–30	2–05	1–54	1–49	1–45	1–43	1–41	1–40	1–39	1–37	1–36	1–34	1–33	1–33	1–32
2.0			1562–00	11–52	4–06	3–13	2–46	2–35	2–29	2–24	2–20	2–18	2–16	2–13	2–10	2–08	2–06	2–05	2–04
2.5			∞	31–00	6–26	4–28	3–48	3–28	3–16	3–08	3–03	2–59	2–55	2–51	2–46	2–45	2–40	2–38	2–36
3.0				96–39	9–54	6–09	5–01	4–28	4–10	3–58	3–49	3–43	3–38	3–30	3–24	3–17	3–14	3–11	3–08
4.0				3124–00	23–43	11–05	8–12	6–57	6–16	5–50	5–33	5–19	5–10	4–58	4–44	4–32	4–26	4–20	4–15
6.0				∞	193–19	35–35	19–48	14–43	12–19	10–55	10–02	9–24	8–57	8–19	7–46	7–15	7–01	6–48	6–34
10.0					∞	728–49	124–00	59–18	39–34	30–39	25–42	22–35	21–32	17–52	15–41	13–57	13–05	12–24	11–42

Duration of exposure (in hours and minutes) required to produce various values of D/R for various values of time of entry after the explosion

emergency supply of electricity should be available to provide lighting and to operate the ventilation system.

10.37. Where shelters are required mainly for protective purposes and not to house vital operational or control activities, much simpler methods can be used. Tunnels cut in a hillside, with entries at right angles to the main tunnel, form very effective shelters. In Nagasaki, such shelters protected persons from blast and from thermal and nuclear radiations very close to ground zero (fig. 10.37).

10.38. If the terrain is flat, several other cheap forms of shelter, which use earth as a protective medium, are possible. In the "cut-and-cover" type, a deep pit or trench is dug, and the sides are shored up with planks and wooden columns. Stout beams are placed across the excavation and upon them are laid sheets of corrugated iron. These are finally covered with a layer of earth at least 3 feet thick. The approach to the shelter is by a right-angled ramp entrance, there being two such entrances to each shelter (figs. 10.38a and b). Digging tools should be available as a further precaution against entrapment by cave-in. A shelter of this kind will provide good protection against all the effects of an air-burst nominal atomic bomb beyond one-half mile or so from ground zero.

10.39. A half-buried shelter, which is partly above and partly under ground, is similar to, but not quite so good as, the type just described. These are very simple to construct. Wood may be used for roofing in place of the corrugated sheets, but it is, of course, less permanent. A baffle of earth and boards at the entrance is desirable, to prevent direct access of blast and radiation. In Japan, half-buried shelters were made of a framework of poles, over which was placed tarpaulins; the whole was then covered with a thick layer of soil (fig. 10.39).

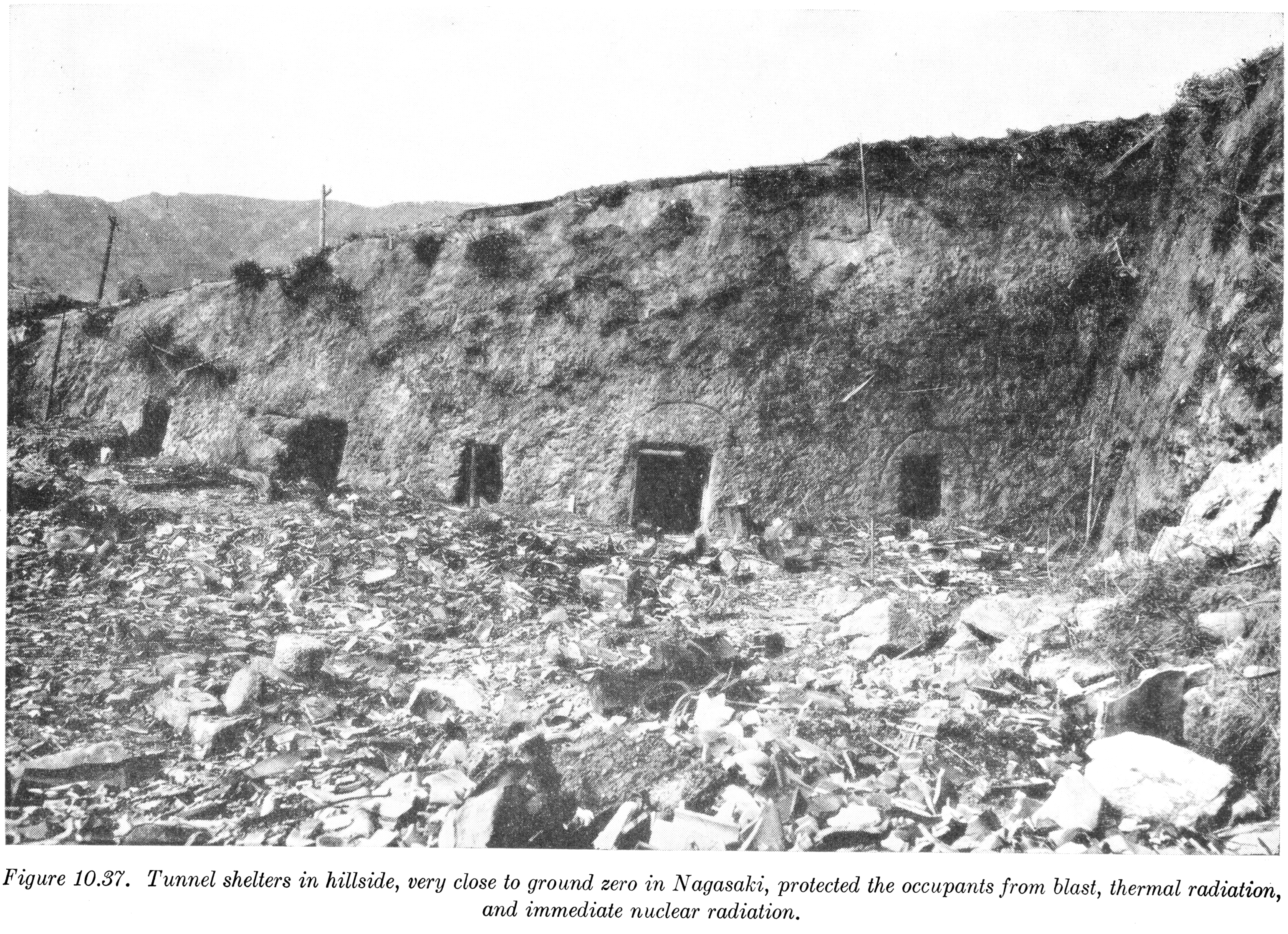


Figure 10.37. Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

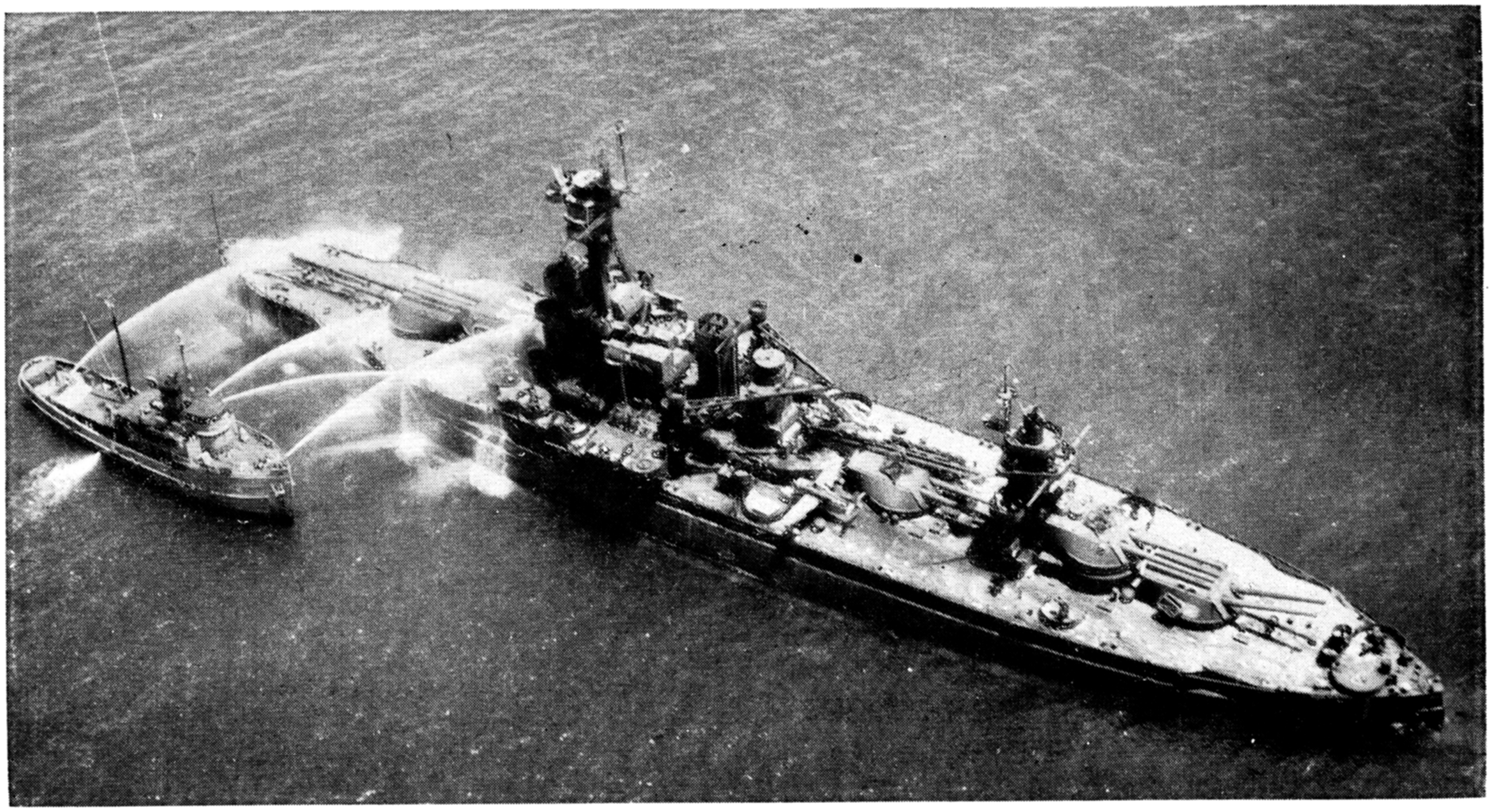


Figure 12.96. Rough decontamination of the NEW YORK, after Test Baker at Bikini, by hosing down with sea water from a Navy rescue tug.

sion, especially in places where deterioration is likely to exist unobserved. Such places are boiler seatings, stack breachings, sea chests, hull fittings, and bulkheads and frames in tank spaces, etc. These inspections assume added importance in view of the possibility of atomic attack. Corroded surfaces are particularly susceptible to contamination, and deteriorated places are, of course, those which are likely to give way under the influence of blast and shock.

12.99. Following an underwater burst the base surge will constitute a possible hazard. However, if the interior of the ship is water-tight and the ventilation system is shut down completely, the entry of the base surge can be prevented. Since about a minute will elapse before the base surge overtakes a moderately undamaged ship, there should be time for personnel to take appropriate cover and for the ship to be secured by closing all ventilation intakes, doors, and hatches. This is an operation which can be planned and practiced in advance, so that it can be performed as quickly as possible. Within 5 minutes the base surge probably will have dissipated, and emergency control operation can be started.

12.100. It was stated in paragraph 11.38 that if topside structures are wetted with sea water before an atomic attack, contaminated particles can subsequently be removed much more readily. It is expected that, where practicable, future ship design will make provision for a "water curtain" for flushing weather surfaces prior to an attack, and for subsequent possible decontamination. Generally, however, the ship's fire hoses may be used to drench all exposed topside surfaces. Trial experiments will indicate how quickly the wetting-down operation can be performed. In the event of an alert, the commanding officer will then have some idea of whether members of the crew have time to spray important exposed areas.

12.101. Since porous materials cannot be decontaminated once they have soaked up radioactive material, manila and canvas should be stowed, if possible, where they cannot be wetted by rain or spray.

12.102. After an air burst there will be no base surge, but the nuclear radiation emitted at the time of explosion is just as lethal. Since 50 percent of this radiation is given off within a second of the explosion, there will only be time, at best, for an individual in the open to drop to the deck after seeing the flash of the explosion.

CONCLUSION

There has been a tendency to attach too much of an element of mystery to atomic weapons and their effects. It is hoped that this book has helped to dispel any such feeling which may have been in the minds of some of its readers. Familiarity with the probable effects of new weapons is an important first step in planning how to deal with them under various conditions. In the case of atomic weapons, most of these effects are known to our Armed Forces from previous wartime experience with other explosives, so that the difference is principally one of degree. Even the nuclear radiation, although not heretofore encountered in military weapons, is similar in many respects to chemical warfare from the standpoint of defensive measures.

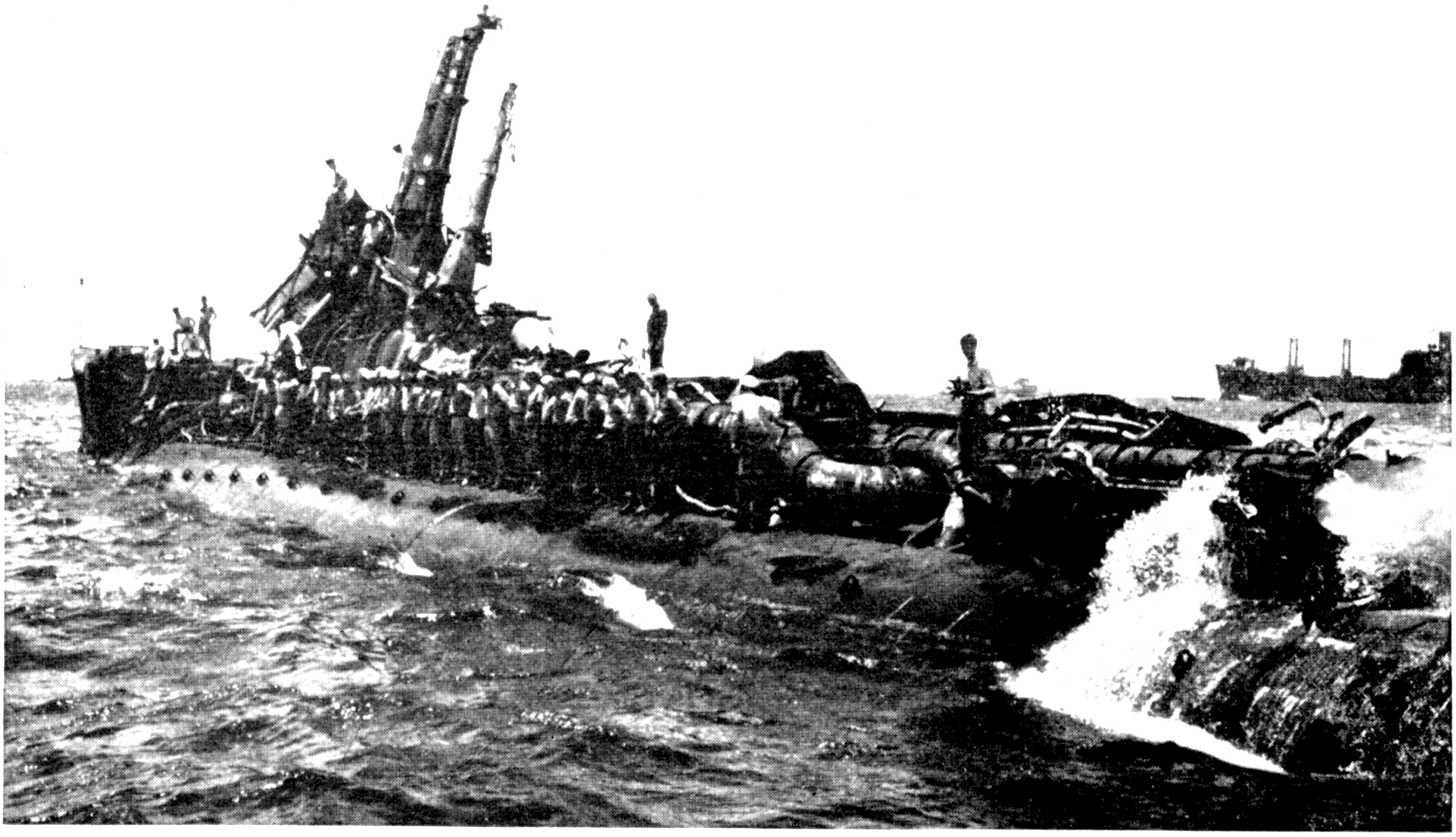
No radical changes in organization are required for military defense against atomic weapons; only a few minor changes and additions in specialist personnel are necessary. Much of the equipment needed has already been provided for other purposes; the balance is being rapidly supplied. The remaining—and continuing—task is to achieve a proper level of indoctrination and training in the field, and to observe whatever defensive precautions are consistent with the military situation.

OPERATION CROSSROADS

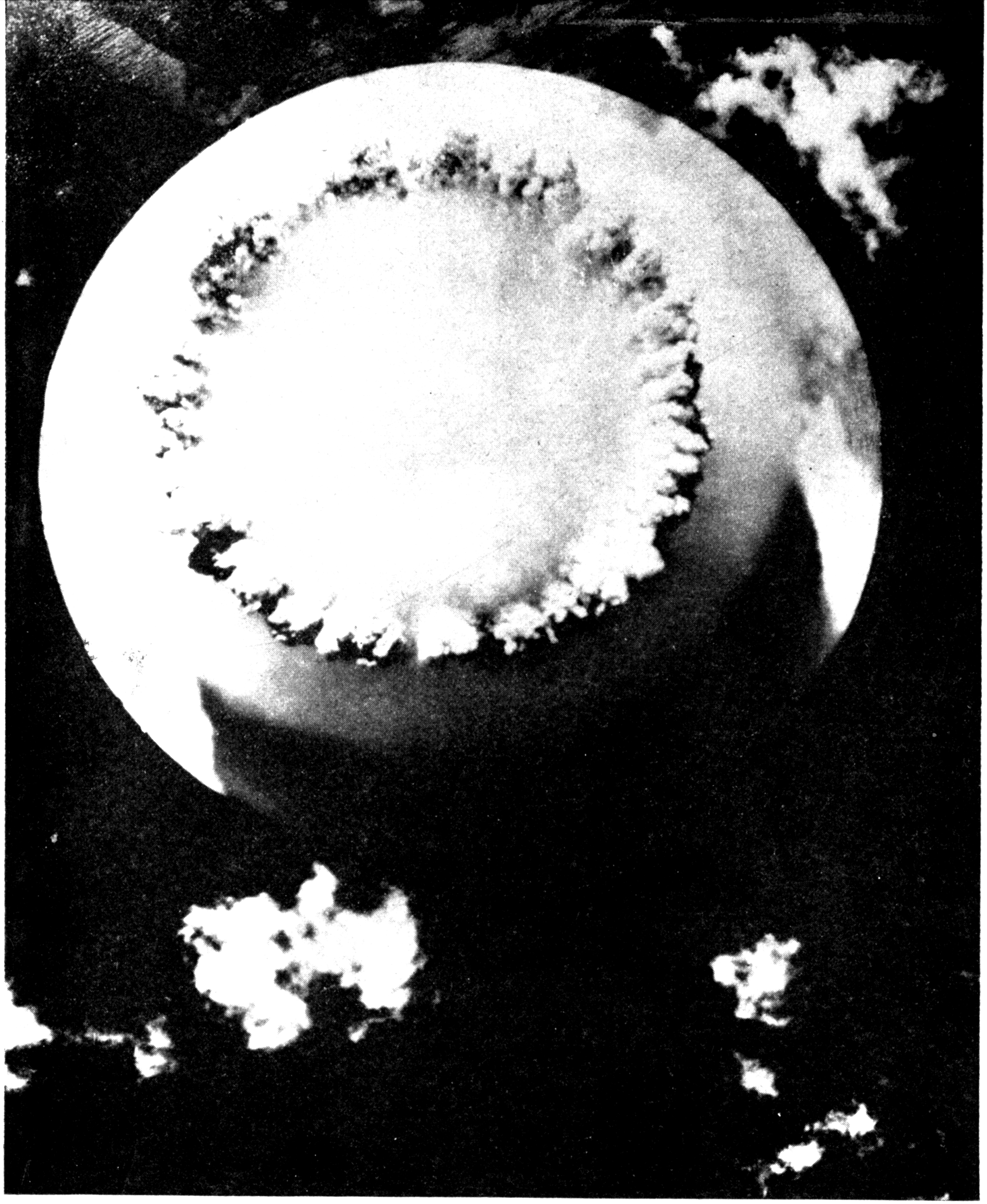
The Official Pictorial Record

The Office of the Historian
Joint Task Force One

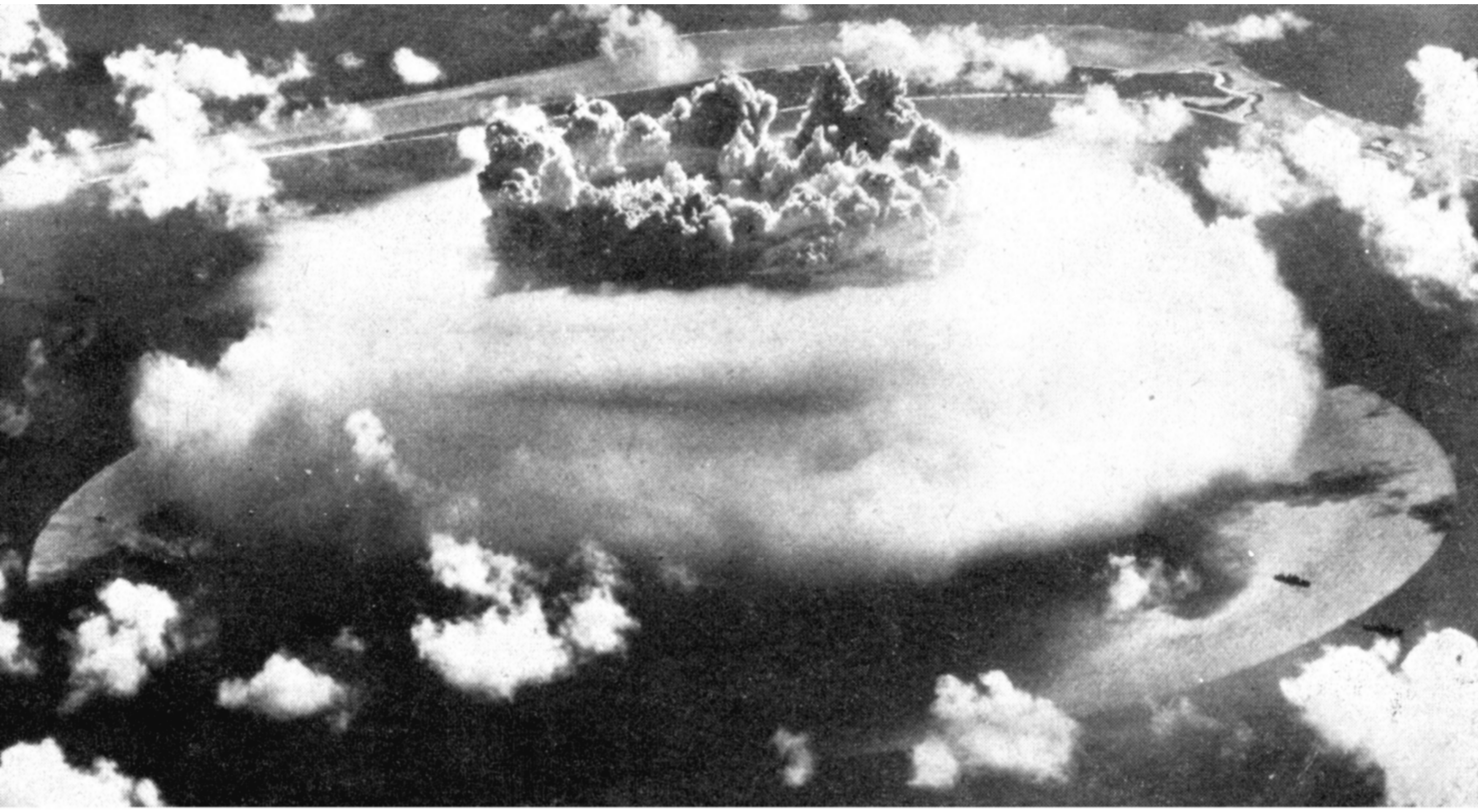
1946
Wm. H. Wise & Co., Inc.
New York

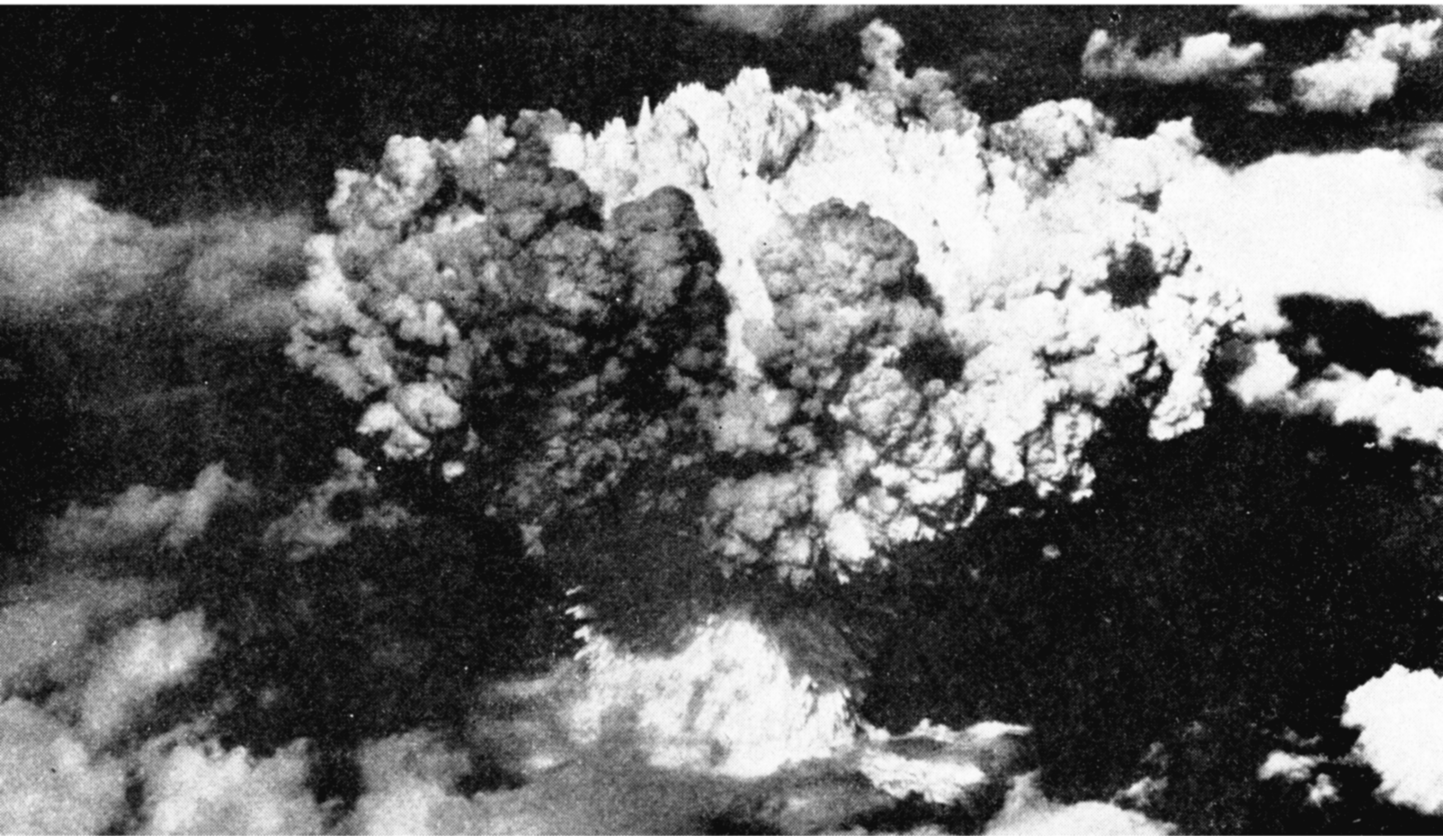


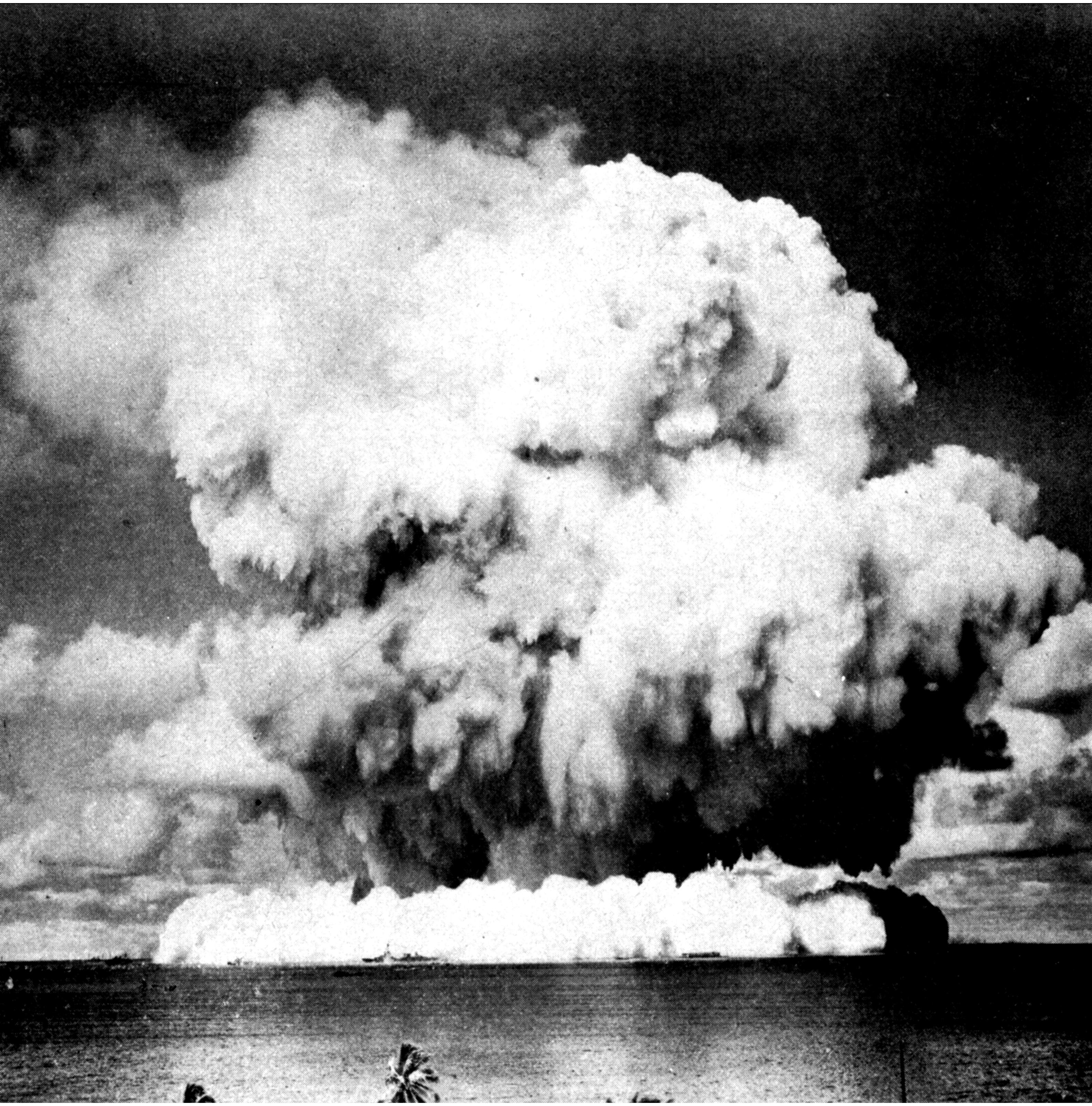
TIN FISH, OR RHINOCEROS? The submarine "Skate" was one of the target ships close to the explosion point of the bomb, the blast and heat from which turned her superstructure into a mass of scrap. Her tough hull refused to succumb to the bomb's onslaught, however. She was put back into operation by her crew a few days after Able Day, although the damage to superstructure still made it unsafe to submerge her. UPPER. Crew of "Skate" stands at quarters as the sub passes Admiral Blandy's flagship. LOWER. Damage to periscope shear. OPPOSITE, UPPER. "Skate" in pre-Test condition. LOWER. Portside view of damage.

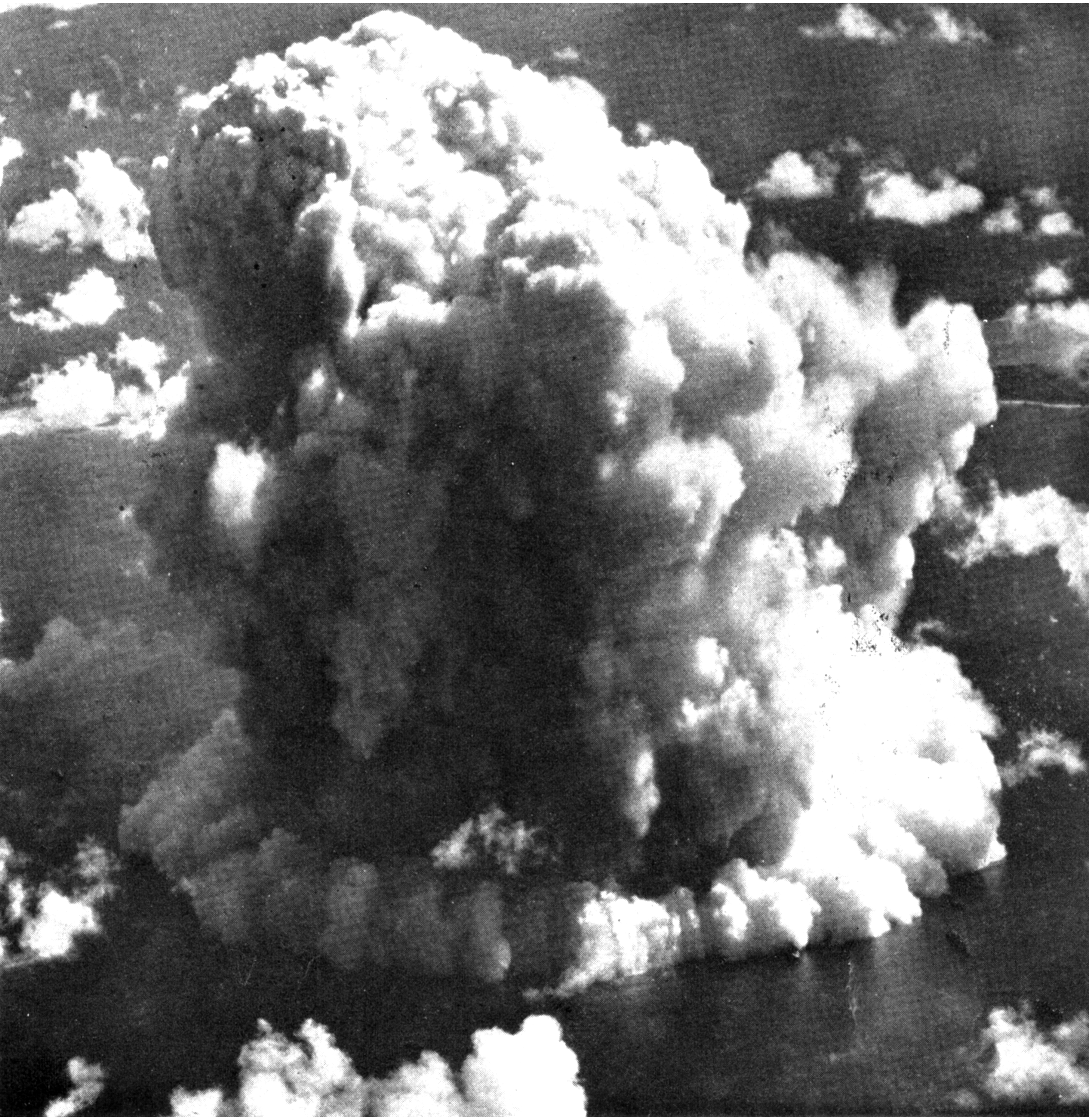


HIGH ALTITUDE VIEW, BAKER TEST. This almost perfect birdseye view of the Baker burst was taken from directly overhead by a drone photographic airplane arriving exactly on schedule. To aid discussion of pictures like this, Task Force scientists developed their own terminology. In this photograph the rough central portion, or "cauliflower", is still in an early stage. Water which lay motionless a second before is now arising toward the camera with the speed of a bullet, spreading slightly as it rises. The surrounding white disc-shaped area, concentric with the cauliflower, is called the "fillet." It denotes the spread of the extremely intense pressure wave.









DEPARTMENT OF THE ARMY PAMPHLET 39–1

THE TACTICAL USE OF ATOMIC WEAPONS

UNCLASSIFIED MILITARY EFFECTS

DEPARTMENT OF THE ARMY MARCH 1955

Weapons		Capability for type of burst					Available delivery systems								
Type	Yield (KT)	Air burst		Surface burst	Under-ground burst	Prepo-sitioned burst	Artillery		Free rocket		Guided missile		Air delivery		Prepositioned (CEP always zero)
		High [1]	Low [2]				Maximum range (yd)	CEP [3] (yd)	Range (miles) (assumed)	CEP (yd)	Range (miles) (assumed)	CEP (yd)	High-altitude release CEP (yd)	Low-altitude release CEP (yd)	
ABLE	2	Yes	Yes	No	No	No	30, 000	[3] 0	No capability		No capability		No capability	500	No capability
BAKER	15	Yes	Yes	No	No	No	30, 000	[3] 0	10–25	500	20–150	500	No capability	500	No capability
CHARLIE	20	Yes	Yes	Yes	Yes	Yes	30, 000	[3] 0	10–25	500	20–150	500	1, 000	500	[4]
DOG	75	Yes	Yes	No	No	No	No capability		10–25	500	20–150	500	1, 000	500	No capability
EASY	100	Yes	Yes	No	No	No	No capability		10–25	500	20–150	500	1, 000	500	No capability
FOX	200	Yes	Yes	No	No	No	No capability		No capability		No capability		1, 000	No capability	No capability
GEORGE	500	Yes	Yes	No	No	No	No capability		No capability		No capability		1, 000	No capability	No capability

[1] Scaled from 2,000 ft for the 20-KT weapon.
[2] 1½ times radius of fireball (fireball volumes assumed proportional to yield).
[3] Use Zero CEP in all instances except troop safety. Use CEP=100 yards for troop safety.
[4] Normally used only for surface or underground bursts, but see notes to figures 2, 3, and 4.

Figure 1. Weapon-burst-delivery capabilities.

Weapon type and yield	Type burst	Built-up areas and personnel in built-up areas [1] (i. e., cities)	Command posts [2]	Materiel damage [3 4]				Bridge destruction				Mainte-nance areas [4]	Port facilities
				Trucks (all types)	Tanks and armored vehicles	Artillery (all types)	Communi-cations equipment	Railroad		Highway			
								0-350 feet	350-550 feet	0-250 feet	250-550 feet		
ABLE (2-KT)	High air	825	1, 400	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	370
	Low air	620	1, 050	210	85	175	450	280	210	175	260	280	280
BAKER (15-KT)	High air	1, 610	2, 740	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	730
	Low air	1, 210	2, 060	410	170	340	890	545	410	340	510	545	545
CHARLIE (20-KT)	High air	1, 775	3, 000	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	800
	Low air	1, 330	2, 250	450	190	375	975	600	450	375	565	600	600
	Surface	1, 330	2, 250	450	190	375	975	600	450	375	565	600	600
	Underground [6]	885	1, 500	300	125	250	650	400	300	250	370	400	400
	Prepositioned [7]	[7]	[7]	[7]	[7]	[7]	[7]	[7]	[7]	[7]	[7]	[7]	[7]
DOG (75-KT)	High air	2, 760	4, 680	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	1, 250
	Low air	2, 070	3, 520	700	290	580	1, 520	935	700	580	875	935	935
EASY (100-KT)	High air	3, 020	5, 160	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	1, 370
	Low air	2, 280	3, 860	770	320	640	1, 670	1, 030	770	640	970	1, 030	1, 030
FOX (200-KT)	High air	3, 840	6, 480	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	1, 730
	Low air	2, 880	4, 860	975	405	810	2, 100	1, 300	975	810	1, 215	1, 300	1, 300
GEORGE (500-KT)	High air	5, 200	8, 800	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	2, 340
	Low air	3, 900	6, 700	1, 330	550	1, 090	2, 850	1, 750	1, 330	1, 090	1, 650	1, 750	1, 750

[1] Based upon destruction of structures.

[2] Applicable to the field-type command posts given dug-in protection. For command posts in cities use effects radii for built-up areas.

[3] Item damaged seriously enough to render it useless either permanently or until major repairs are accomplished.

[4] For dug-in materiel, use an effects radius equal to *one-half those given in this figure.*

[5] Blast damage from high air-bursts against "materiel," "bridges," and "maintenance areas" is considered militarily negligible.

[6] 50-foot depth of penetration.

[7] *a.* Use surface-burst effects radii when prepositioned on the surface or at depths up to 25 feet.

b. Use underground-burst effects radii when prepositioned underground (or underwater) at depths from 26 to 50 feet.

c. Do not preposition underground (or underwater) at depths greater than 50 feet.

d. Use surface-burst effects radii when prepositioned above ground in buildings regardless of building height.

Figure 2. Effects radii (R_e) for air blast.

(Distance in yards from ground zero)

Section IV. RESIDUAL RADIATION

19. General

The residual radioactivity is that which remains after the immediate effects of the detonation are over. It consists of gamma rays and particles from the fission products which have escaped fission. When the radioactive particles of fission products collide with dust particles they may adhere. Consequently, if there are dirt particles in the atomic cloud they may become contaminated with radioactivity. When the atomic cloud has dispersed, the radioactive particles will fall back to earth. This effect is referred to as fallout. It is because of the hazard it represents that fallout must be considered. In an air burst the fallout is a negligible hazard. But in a surface burst or an underground burst, because of the great amount of dust drawn up by the burst, fallout is not at all negligible.

20. Underground Burst

In an underground burst a considerable volume of material is thrown into the air. Much of this material will fall directly back into the crater because of its weight. Some will fall out at greater distances from ground zero. Figure 6, which has been patterned after BIKINI BAKER data revised to accord to estimates for an underground burst, presents an estimate of the radiation dosage rate in roentgens per hour on the ground 1 hour after an underground burst of weapon CHARLIE. Figure 6 assumes a wind of 5 miles per hour. If the underground detonation should be accompanied, or followed, by high winds due to natural causes, large amounts of contaminated dirt may be carried away, as in a duststorm. If for any reason much of this should fall in one area, perhaps carried down by rain, a serious radiation hazard might be created. The possibility of such an occurrence must be kept in mind. For simplicity no estimates of residual radiation for other than a 5-mile wind velocity are presented in this text.

21. Surface Burst

In a surface burst a lesser volume of material is thrown into the air than in an underground burst. A distinct problem of residual radiation, nevertheless, must be reckoned with. Figure 7, which is based on ALAMAGORDO data revised for a 5-mile-per-hour wind, presents an estimate of the radiation dosage rate in roentgens per hour on the ground 1 hour after a surface burst of weapon CHARLIE. Again, if high winds should accompany or follow the detonation, a serious radiation hazard might be created. For simplicity no estimates of residual radiation for other than a 5-mile wind velocity are presented in this text.

22. Decay of Fission Product Activity

The direct products of fission start to decay as soon as they are formed. They continue to decay until ultimately the activity of the fission products becomes negligible. The rate at which they decay has been determined from experimental measurements. Figure 8, "Chart for estimation of dose rate at various times after an atomic explosion," is based on the results of these measurements and enables determination of the dosage rate in roentgens per hour at any given time provided only that the dosage rate 1 hour after detonation is known.

a. First Example of Use of Figure 8. At 1½ hours after an atomic explosion, the radiation dose rate at a certain place, due to fission products, was found to be 8 roentgens per hour. What would it be after 24 hours?

The arrow (1) in the reproduction of figure 8 below indicates the time "1½ hours" after the explosion, and arrow (2) shows the dose rate "8 roentgens per hour." These establish a point marked *a*, which represents the information given. A line through *a*, parallel to the others in the figure, will then indicate the change of radiation intensity with time at the place under consideration. The dose rate at 24 hours after the explosion is found by following this line from *a* to *b*, where it meets the vertical line for "24 hours" after the explosion, indicated by arrow (3). The dose rate at *b*, which is the required answer, is then obtained by finding the corresponding reading on the vertical scale. Following the horizontal line from *b* to *c*, this is seen to be 0.28 roentgens per hour.

b. Second Example of Use of Figure 8. At 30 minutes after an atomic explosion, the radiation dose rate, due to fission products, was found to be 260 roentgens per hour. How long will it be necessary to wait until the dose rate at this place falls to 1 roentgen per hour?

The arrow (1) in the reproduction of figure 8 below indicates "0.5 hour," i. e., 30 minutes, after the explosion, and arrow (2) shows the dose rate

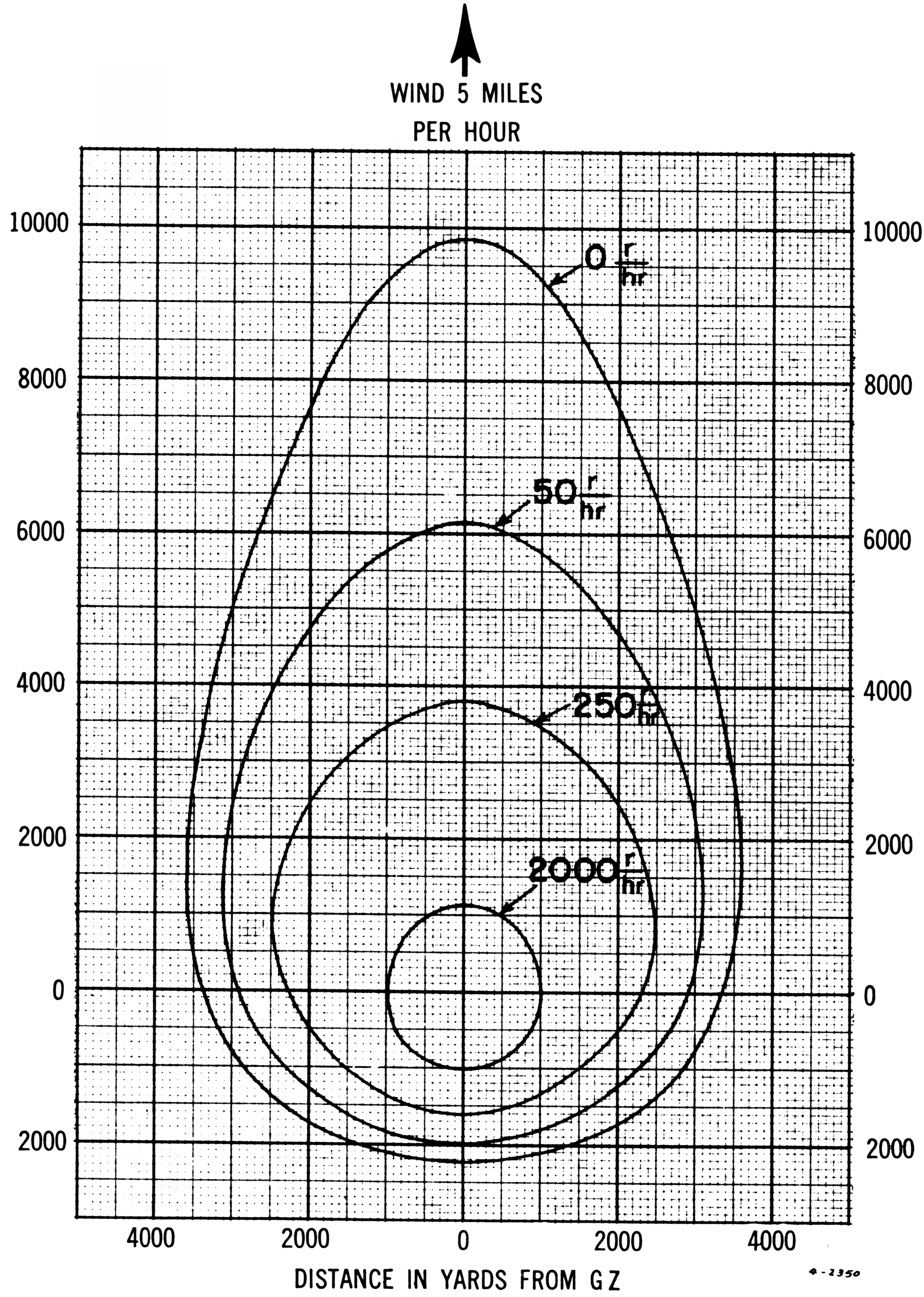


Figure 6. Estimated radiation dosage rate in roentgens per hour on ground 1 hour after detonation of a 20-KT underground burst.

(Derived from BIKINI BAKER)

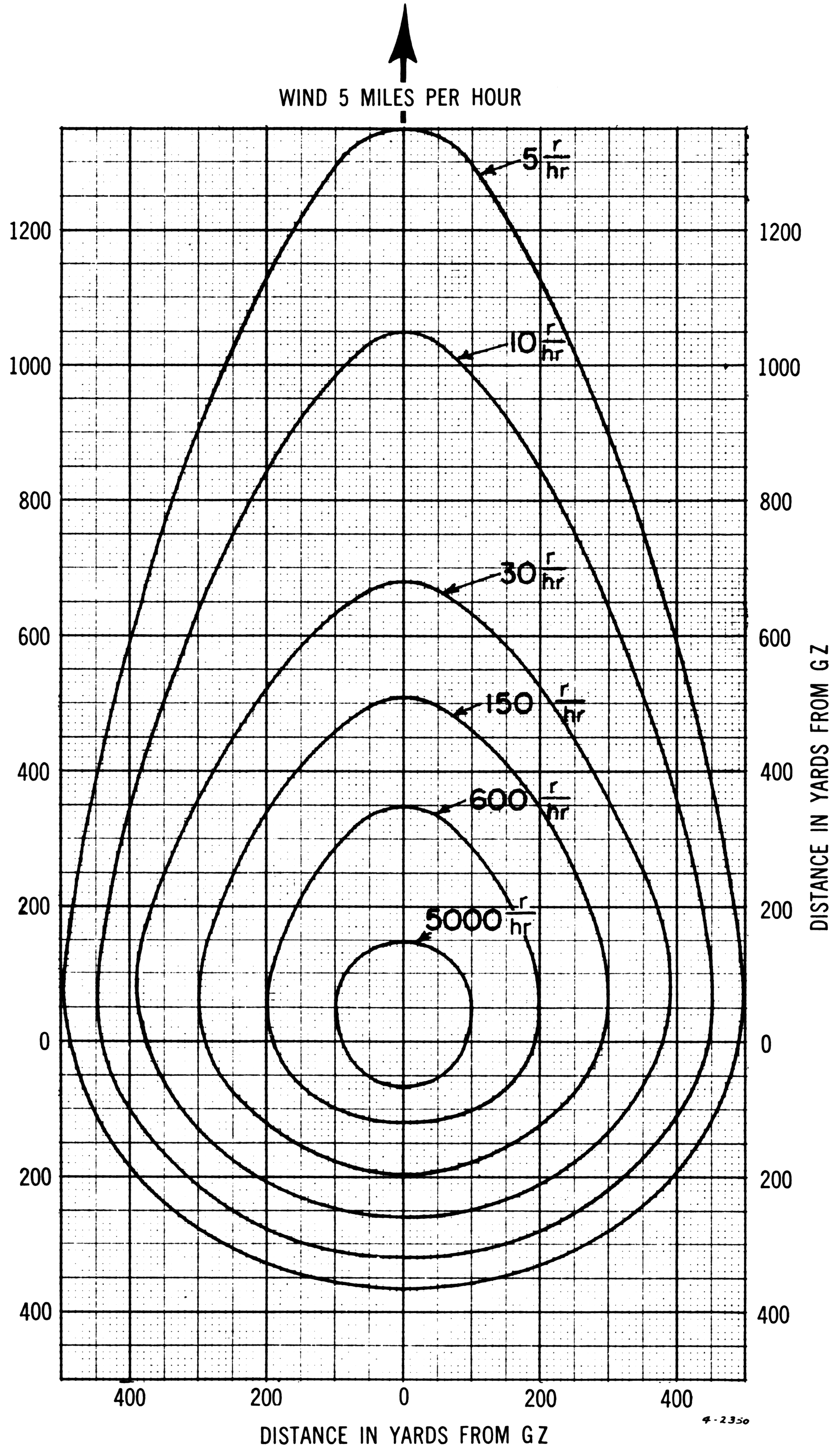


Figure 7. Estimated radiation dosage rate in roentgens per hour on ground 1 hour after detonationof a 20-KT surface burst.

(Derived from ALAMAGORDO DATA)

DEPARTMENT OF THE ARMY PAMPHLET NO. 39-1

ATOMIC WEAPONS EMPLOYMENT

DEPARTMENT OF THE ARMY JUNE 1956

FOR OFFICIAL USE ONLY

PAMPHLET No. 39–1

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *12 June 1956*

ATOMIC WEAPONS EMPLOYMENT

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*** This pamphlet supersedes DA Pam 39–1, 11 March 1955.**

CHAPTER 1

WEAPONS SYSTEMS

Section I. WEAPONS AND BURST HEIGHTS

1. General

a. The yields of atomic weapons are rated in terms of their total energy release expressed in kilotons or megatons of TNT. One kiloton is 1,000 tons. Hence, a weapon capable of releasing an amount of energy equivalent to that released by 20,000 tons of TNT is referred to as a 20-kiloton (20-KT) weapon. A megaton is 1,000 kilotons or 1,000,000 tons. A weapon capable of releasing an amount of energy equivalent to that released by 1,000,000 tons of TNT is referred to as a 1-megaton (1-MT) weapon. In the series of weapons assumed for the purposes of this text, there are 10 weapons ranging from 2-KT to 5-MT (table VI).

b. Table VI contains a list of assumed weapons with assumed yields and delivery capabilities. Any assumed weapon could be delivered by any assumed delivery means. For the purpose of this text the delivery capabilities of the assumed weapons are restricted to those as shown in table VI.

2. Types of Weapons

a. Atomic weapons can be classified according to the delivery means used to place the weapon on or over the target. There are bombs deliverable by aircraft, warheads deliverable by free rockets and guided missiles, and artillery shells capable of being fired by guns. In addition, certain weapons can be prepositioned. Of the 10 weapons used in this text, 3 are capable of being fired by guns, 5 by free rockets, and 9 by guided missiles, and 10 can be delivered by aircraft.

b. Atomic weapons can be burst in the air over a target, on the surface of the target or beneath the surface of the earth after having penetrated the target. All of the weapons used in this text are capable of producing air bursts; 1 can be burst underground; 2 can be prepositioned; and 3 can be burst on the surface.

3. Burst Capabilities

a. High Air Burst. The first eight weapons (table VI) are given a high air burst capability. The INDIA and JULIETT weapons are not capable of a high air burst. The height of burst is based on 2,000 feet for the 20-KT weapon. For other yield weapons the high air burst height has been determined by appropriate scaling.

b. Low Air Burst. All 10 weapons are given a low air burst capability. The height of burst is approximately one and one-half times the fireball radius, or about 675 feet for a 20-KT weapon.

c. Surface Burst. The CHARLIE (20-KT), INDIA (1-MT), and JULIETT (5-MT) weapons have been given a surface burst capability. For a description of surface burst, see paragraph 15.

d. Underground Burst. The only weapon given an underground burst capability is the CHARLIE (20-KT) weapon. For a description of an underground burst, see paragraph 14.

Section II. DELIVERY SYSTEMS

4. General

a. There are five means of delivering atomic weapons: aircraft, free rocket, guided missile, gun, and prepositioning. In selecting a means of delivery a number of factors must be considered:

(1) *Weapon type.* The types of weapons allocated have a direct bearing on the means of delivery.

(2) *Enemy countermeasures.* The different means of delivery have varying degrees of

susceptibility to neutralization by enemy countermeasures.

(3) *Terrain and weather conditions.* Certain terrain and weather conditions may make some means of delivery unacceptable because of the uncertainties or the probable inaccuracies of the delivery means.

(4) *Coordination with maneuver.* The use of atomic weapons must be coordinated with the scheme of maneuver. If a choice of delivery means exists, the delivery means best fitted to the maneuver plan should receive first consideration. If only one delivery means is available, the maneuver plan may have to be adjusted to fit the delivery means.

(5) *Degree of accuracy required.* The accuracy required depends on the damage desired, the type of target, and the proximity of friendly troops.

(6) *Effective range.* Each means of delivery has its own range limitations. Delivery units may have to be displaced to ensure adequate range.

(7) *Tactical surprise.* Care must be exercised that tactical surprise in the delivery of atomic weapons is not jeopardized by actions of the delivery, surveillance, or reconnaissance agencies.

b. For a tabulation of delivery systems applicable to individual weapons, see table VI.

5. Aircraft Delivery

a. The principal advantages of delivery by aircraft lie in the great ranges which are possible and in the inherent flexibility of this delivery means. For the 10 weapons assumed for purposes of this text, aircraft delivery permits the selection of any yield desired and permits either high or low air bursts as indicated in table VI. A surface-burst option is available only for the CHARLIE, INDIA, and JULIETT weapons. Aircraft delivery permits selection of targets over the greatest battlefield area.

b. The principal limitations of aircraft delivery are weather, navigational problems, enemy countermeasures, and the inaccuracies of high level bombing. The slow speed of aircraft compared to rockets, guided missiles, and gun-fired projectiles permits enemy detection and countermeasures to be more effective. This may cause loss of surprise or have an adverse effect on the success of the mission.

6. Free-Rocket Delivery

a. Free-rocket delivery is defined as delivery by unguided preset rockets. In the close support of ground operations, this method of delivery has important advantages. The free-rocket has adequate range and flexibility for normal tactical use. The reliability normally is higher than the reliability of delivery by guided missile.

b. The free-rocket delivery method is comparable in range to the gun-delivery method. The range is considerably less than guided missile or aircraft ranges. Thus launching sites may be vulnerable to enemy artillery action. This disadvantage is aggravated by the difficulty in concealing the quantity of smoke and flame discharged by the rocket motor.

c. Of the 10 weapons assumed for this text, only the BRAVO (10-KT), CHARLIE (20-KT), DELTA (50-KT), ECHO (75-KT), and the FOXTROT (100-KT) weapons can be delivered by free-rocket.

7. Guided Missile Delivery

a. Guided missile delivery is defined as delivery by guided missiles irrespective of the guiding principle utilized. The principal advantages of this method of delivery are speed, range, and the fact that weather in the target area has little or no effect on missile delivery. With proper survey, the accuracy of delivery is of a relatively high order and permits close coordination with tactical maneuver. Within range limitations, guided missiles have a relatively high degree of certainty of delivery due to speed and the resultant difficulty of enemy interception and destruction in flight. Speed also enhances the possibility of achieving tactical surprise.

b. There are several limitations on delivery by guided missiles. The requirement for guidance data demands accurate survey of the area of employment. These data may not be readily available for the particular area of intended operations. A guidance system which depends upon electronic means for navigation and target recognition may be subject to electronic countermeasures. The time required to prepare a guided missile for delivery is usually greater than the time required for preparing free-rocket delivery or gun delivery.

c. Of the 10 weapons assumed for purposes of this text only one weapon—the ALFA (2-KT) weapon—cannot be delivered by guided missile.

8. Gun Delivery

a. Gun delivery of atomic weapons in close support of ground operations has few of the limitations of the aircraft, free-rocket, and guided missile methods. The gun has adequate range and flexibility for close support and does not require the relatively elaborate logistical facilities of other methods, thus saving time between the decision and actual delivery. Artillery shells are the least susceptible to enemy countermeasures while in flight and are capable of being accurately delivered under almost all conditions of visibility and weather.

b. The gun delivery means has a more restricted range than free-rocket, guided missile, or aircraft. This requires the artillery piece to be closer to the enemy, resulting in comparatively greater vulnerability.

c. Of the 10 weapons assumed for purposes of this text, only the ALFA (2-KT), BRAVO (10-KT), and the CHARLIE (20-KT) weapons can be delivered by the gun delivery means.

9. Prepositioning

a. Prepositioned delivery, for purposes of this text, is defined as actual placement of the weapon at the desired point of detonation and firing by some form of remote control or a timer mechanism. Prepositioning a weapon presents the advantage of selecting and accurately placing a weapon where it can achieve maximum destructive effects on a particular target. The weapon can be detonated following, or in conjunction with, a withdrawal of friendly troops and civilians from the area. The prepositioning method can be used effectively for demolishing natural or manmade features, the destruction of which may be impracticable by other means. The risk of having the weapon seized by the enemy is always present.

b. Of the 10 weapons assumed for the text, only the CHARLIE (20-KT) and the JULIETT (5-MT) weapons can be prepositioned. It is further assumed that these two weapons, when prepositioned, may be fired at any time during a 7-day period after emplacement.

10. Delivery Error

No delivery system is capable of delivery without error in all cases except the prepositioning means of delivery. Different delivery systems are liable to have different types of delivery (or impact) distribution patterns. Distribution patterns are either generally circular or generally elliptical (noncircular). For simplicity, it has been assumed that all of the assumed delivery systems have circular distribution patterns. This is a reasonable assumption, especially when the direction of flight for air delivery; the gun-target line; or missile or rocket launcher site-target line is unknown. This assumption does not result in serious error. For circular delivery patterns, the relative accuracy of delivery systems is expressed as circular error in probability (CEP). By definition, one CEP is the radius of a circle about the center of impact which will contain 50 percent of all weapons employed. For the purposes of this text, assume the center of impact coincides with the aiming point. For gun delivery this error is so small that the CEP is assumed zero, except that for troop safety risk determination a CEP of 100 yards should be used (par. 63). For a tabulation of CEP's applicable to the various weapons and delivery systems, see table VI.

11. Employment Planning Times

Assumed planning times from the decision to employ (or request) the weapons to the time on target are as follows:

Delivery means	Assumed planning times	Time between successive rounds
Gun	30 minutes	1 round per gun per 15 minutes.
Free rocket	1 hour	1 round per launcher per 30 minutes.
Guided missile	2 hours	1 round per launcher per hour.
Aircraft	*4 hours	Not applicable.

* In the case of aircraft strikes, when aircraft are on ground alert, use 60 minutes (including 30 minutes flight time).

These times are exclusive of the times required to calculate fire data which are concurrent with weapons preparation. They are based on the assumption that the weapons are readily available at the firing sites or air bases.

CHAPTER 2

ATOMIC WEAPONS EFFECTS

Section I. DESCRIPTION OF AN ATOMIC DETONATION

12. General

a. The atomic detonation resembles a high explosive detonation in that the explosive effect is the result of the very rapid liberation of a large quantity of energy in a relatively small space. But atomic detonations differ in three important aspects: first, the amount of energy is thousands of times as great as that produced by even the largest high explosive weapons; second, the energy released consists of intense heat, light, and penetrating nuclear radiation as well as blast; and third, under some burst conditions residual radioactivity may be produced which may be significant from a military and civil defense point of view.

b. A knowledge and understanding of the characteristics of blast, heat and light, and nuclear radiation from an atomic detonation are of vital importance. Of equal importance is an understanding of the response of various types of target elements to the principal atomic weapon effects.

c. In a discussion of the effects of atomic detonations, particularly in a quantitative discussion, the term ground zero (GZ) is often used. Ground zero is the spot on the ground over which an air burst weapon is detonated, at which a surface detonation occurs, or under which an underground or underwater detonation takes place. Horizontal distances along the ground to which various intensities of effects extend are measured from ground zero.

13. Air Burst

a. When an atomic weapon detonates in the air, a large sphere of hot, luminous gases is formed. This is called the fireball. The size of the fireball depends on the yield. The fireball from a nominal 20-KT weapon is about 300 yards across at maximum size and is about 30 times as brilliant as the sun at noon. Initially, the fireball contains all the energy of the detonation. Because of the very high temperature of the fireball, it radiates its heat (and light) out into the target area. The heat and light are referred to as *thermal radiation;* its emission from the fireball occurs in the first few seconds of detonation. For one test shot in Nevada the flash of light was observed 400 miles away.

b. The detonation process releases large amounts of nuclear radiation in the form of gamma radiation, alpha and beta particles, and neutrons. This nuclear radiation is emitted or radiated from the fireball in the first moments of the detonation. Most of it appears in the target area in the first 2 seconds after detonation; after 1 minute no significant nuclear radiation is received in the target area. The fireball continues to give off nuclear radiation, principally gamma radiation, for some time, but after one minute the fireball is so high the gamma radiation does not reach the ground. The nuclear radiation which emanates from the fireball in the first minute or so after the detonation is called *prompt nuclear radiation.*

c. As the fireball expands rapidly in the first moments of detonation, it pushes outward a large volume of air. This outward push generates a *blast wave* in the air which continues to travel in the air with a velocity approximately equal to the speed of sound.

d. Approximately half of the energy of the detonation appears as blast, one-third as thermal radiation, and the rest as nuclear radiation. The characteristics of these principal weapon effects will be discussed in subsequent sections.

e. Shortly after detonation the fireball rises and cools. Its rate of rise is quite rapid and it reaches high altitude in a few minutes. The cooling and condensing of the fireball results in the mushroom head of the familiar atomic cloud. The initial rapid rate of rise of the fireball causes air to be drawn inward and upward. Dust and dirt from the target surface are also drawn up to form the stem of the atomic cloud.

14. Underground Burst

a. When an atomic weapon is detonated below the earth's surface, the expansion of the fireball imparts an upward and outward force to the surrounding earth. A large volume of earth and rock is thrown out, leaving a crater. Some of the earth falls back into and around the crater. Except in the case of very deep underground bursts, probably below 600 feet, the fireball vents up through the ground. However, by the time it comes up through the surface the fireball has given up most of its mechanical shock energy to the ground in the formation of a crater. Therefore, air blast resulting from an underground burst is very much less than from an air burst. Except for a relatively weak flash that appears when the fireball vents the surface, almost all the heat and light—thermal radiation—is released into the ground in an underground burst. Hence, above ground, thermal effects are negligible.

b. The nuclear radiation products released by the detonation process are entrapped and absorbed by the ground. However, the soil which absorbs the nuclear radiation is thrown upward and outward. When it falls back to the ground it contaminates the area with residual radioactivity. From an underground burst, then, there is in the target area no significant thermal radiation, greatly reduced blast effects, and no prompt nuclear radiation.

c. When the earth in the vicinity of an underground burst is thrown upward, it produces a characteristic column. The heavier particles in the column fall back to earth and produce a concentric cloud of dust which expands outward from the burst point. This cloud is called the *base surge.* The finer dust particles of the column remain suspended as a cloud in the air for some time before eventually falling to earth. The atomic cloud from an underground burst does not rise as high as the cloud from an air burst; moreover it is discolored by the fine particles of soil entrapped in it.

15. Surface Burst

a. The characteristics of a land surface burst are, in general, intermediate between those of an air burst and an underground burst. Consider first a contact surface burst on land. Since the fireball, in a surface burst, forms above the ground, its rapid expansion generates a blast wave. However, some of the mechanical energy of the expanding fireball is transmitted to the earth under the fireball so that air blast from a surface burst differs from air blast from an air burst. Since the weapon detonates close to the earth, the air blast is very strong near the burst point but the blast pressures fall off more rapidly with increasing distances from burst point.

b. The thermal characteristics of a surface burst are essentially the same as for an air burst; i.e., just about as much heat and light are radiated in each case for weapons of the same yield. The area of effectiveness of thermal radiation in a target area is less from a surface burst than from an air burst. This is due to the fact that thermal radiation from a surface burst weapon arrives in the target at very acute angles of incidence, and minor terrain irregularities, buildings, and even equipment, provide effective shielding.

c. The prompt nuclear radiation emanating from the fireball of a surface burst weapon is essentially the same as from an air burst weapon of the same yield. However, since the fireball expands against the earth's surface, a considerable portion of the earth under the detonation is irradiated and vaporized. This vaporized, irradiated earth is drawn up by the rising fireball. The combination of vaporization of a portion of the earth's surface and the scooping effect of the expanding fireball produces a crater, similar to but smaller in size than the crater from an underground burst. The heavier particles of rock and soil thrown out by a surface burst will fall back around the burst area. Since this soil has been irradiated it will contribute to residual radioactivity in the area. The vaporized earth drawn up into the fireball will condense when the fireball cools, and fall to earth downwind, producing residual radioactivity in the area of fallout.

d. In those cases where an atomic weapon does not detonate in contact with the earth's surface, but within about 50 feet of the surface, the burst is called a near-surface burst. The effects are practically the same as for a contact surface burst.

16. Bursts in or Over Water

a. When an atomic weapon is burst in the air over water, the blast, thermal radiation, and prompt nuclear radiation are essentially the same as for an air burst over land.

b. When an atomic weapon is detonated under the surface of a body of water, the column thrown upward consists of water. If the underwater burst occurs in shallow water, the column may include earth from the bottom. The column of water fall-

ing back onto the surface produces a base surge of mist and spray. Some of the energy of the fireball as it expands under water is transmitted to the water and is propagated outward as water shock and water waves on the surface. There is no appreciable thermal or prompt nuclear radiation from an underwater burst, and air blast is less than from an air burst. The water, thrown upward in the column, is irradiated and traps the fission fragments. When this water falls back to the surface, it contaminates the area with residual radioactivity (fallout). The base surge contributes to the residual radioactive contamination. If the fallout and base surge occur over the water, the residual radioactive contamination is soon diluted and dissipated. If the underwater burst occurs in a harbor or near enough to a shore area, the fallout may occur over land which would be more highly contaminated and for longer periods.

c. When an atomic weapon detonates at or near the surface of water, the thermal, prompt nuclear, and blast effects will be essentially those of a land surface burst. However, some of the mechanical energy of the expanding fireball will generate water waves and underwater shock. No crater will form unless the water is shallow. A large volume of water will be vaporized and drawn up into the cloud. When this condenses, it will be deposited as fallout.

Section II. BLAST

17. Blast Wave Characteristics

a. The rapidly expanding fireball of an atomic detonation exerts an outward push on a large volume of air. This compressed air continues to move outward from the burst point as a shock wave at a velocity approximately equal to the speed of sound. The leading edge of the blast wave is an abrupt rise in pressure above atmospheric. The maximum pressure at the shock front is called the *peak overpressure.* Peak overpressure is expressed in terms of pounds per square inch (psi) above atmospheric. It is the magnitude of the peak overpressure which largely determines the degree of damage produced by blast. Following the peak overpressure at the shock front, the pressure gradually drops off to atmospheric, and then to a pressure below atmospheric, followed by a return to atmospheric pressure (fig. 1). Only that portion of the blast wave in which the pressure is above atmospheric—the positive pressure phase—is significant from the point of view of blast damage.

b. The blast wave travels outward from the burst point. As it gets further away, the magnitude of the peak overpressure decreases; hence the destructive effect is lowered.

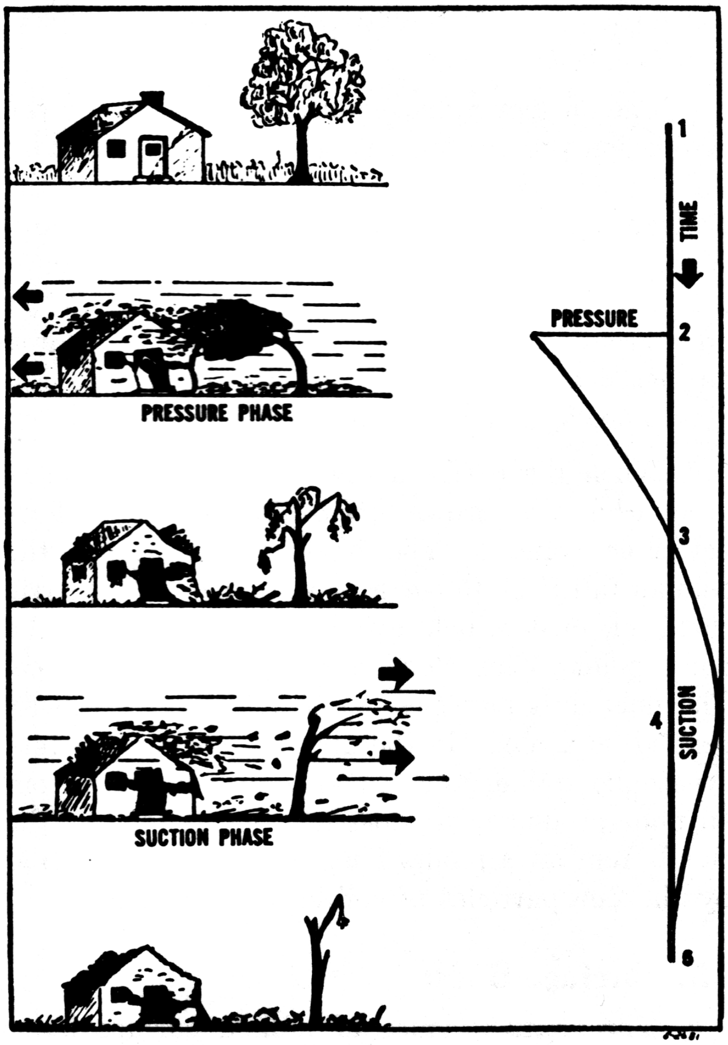


Figure 1. Blast wave effects.

18. Blast Wave Reflection

When the blast wave from an air burst weapon strikes the surface of the earth, it is reflected back. At some distance from ground zero the reflected blast wave merges with the direct blast wave. This merging, called the *Mach* effect, greatly increases the blast peak overpressures on the surface for certain overpressures. This makes the high air burst advantageous for certain types of targets (fig. 2). There is no reflection of blast from a surface or underground burst because there is essentially only one blast wave.

TABLE I. *Effects of Acute Whole Body Doses*

Acute dose	Effects
5,000 r	5,000 r produce immediate and persistent noneffectiveness until death.
1,000 r	Initial sickness appears in 1 hour or less. May be no latent period. No survivors are expected.
650 r	Initial sickness appears in all personnel within 4 hours and lasts for about 1 day. After about 1 week, the latent period is over. Death ensues in about 2 weeks in about 95 percent of the cases. Survivors are noneffective for 6 months.
450 r	Initial sickness appears in all personnel during first day. After about 2 weeks, latent period is over. About 50 percent deaths can be expected but this may be reduced by adequate medical treatment. Survivors are non-effective for 6 months.
300 r	Initial sickness during first day in all personnel. After about 3 weeks latent period is over. About 25 percent deaths may be anticipated but this may be reduced by adequate medical treatment. Survivors are noneffective for 3 months.
200 r	Initial sickness during first day in about 50 percent of personnel. Second period of sickness appears after about 3 weeks and lasts for 1 or 2 weeks. No deaths anticipated unless recovery is complicated by poor health, other injury, or infection.
100 r	Initial sickness in about 2 percent of personnel. All are able to perform duty.

Section V. CRATERING AND GROUND SHOCK

27. Characteristics of Cratering and Ground Shock

a. An atomic detonation on the surface or under the ground results in formation of a crater. Some of the mechanical energy of the expanding fireball throws earth upward and outward. The heavier particles of earth and rock fall back into, and in the vicinity of, the crater. This results in low trafficability as well as high radioactive contamination in the crater area.

b. Some of the energy of the expanding fireball is coupled to the earth itself as a shock wave in the ground. The effects of the ground shock wave are similar to a mild earthquake, but are more localized. Destruction of underground structures is complete in the crater itself, but militarily significant damage caused by ground shock may extend beyond the crater for considerable distance. How far depends on soil characteristics and type of structure.

28. Underground Damage

Table II shows crater dimensions for the various weapons capable of being burst on or under the surface of land targets. The extent to which underground structures may be damaged must be determined from an analysis of the type of target element, soil conditions, and yield of the weapon. Underground utilities such as pipelines, sewers, and gas and water mains are most vulnerable to ground shock. Reinforced concrete foundations, particularly those resting on rock, are least vulnerable. Underground damage will extend 3 times as far in heavy wet clay as in light loam or sandy soil.

TABLE II. *Crater Data*

Weapons	Type of burst	Crater dimensions in average soil		Radius of ground shock in average soil (yds)
		Radius (yds)	Depth (ft)	
CHARLIE (20-KT)	surface	140	210	280
CHARLIE (20-KT)	underground	170	450	400
INDIA (1-MT)	surface	515	765	1,450
JULIETT (5-MT)	surface	880	1,305	2,500

APPENDIX III

TABLES AND FIGURES

TABLE VI. *Weapon-Burst-Delivery Capabilities*

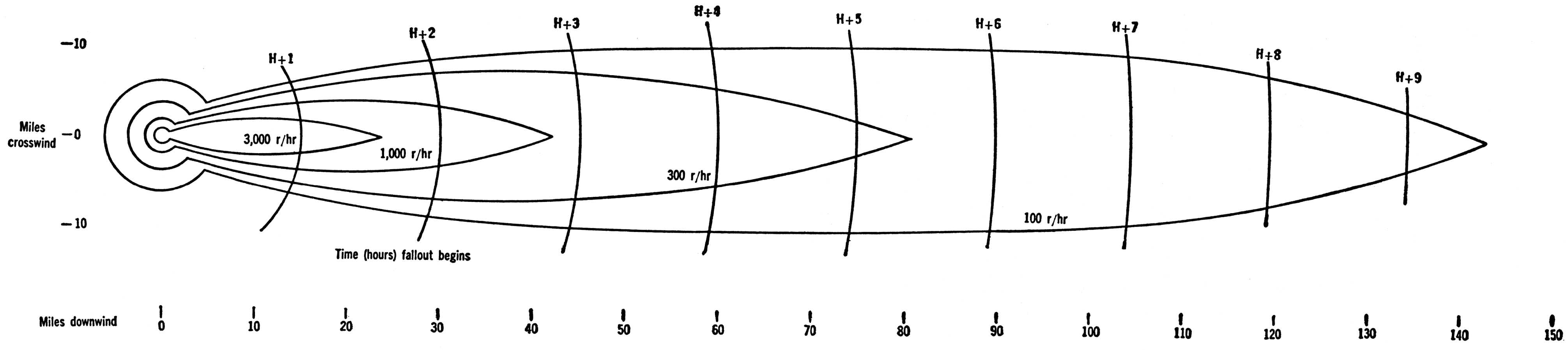
Weapon		Capability for type of burst				Delivery systems							
Type	Yield	Air burst		Surface burst	Under-ground burst	Gun		Free rocket		Guided missile		Aircraft	Prepositioned
		High	Low			Maximum range (yd)	CEP[1] (yd)	Range (miles)	CEP (yd)	Range (miles)	CEP (yd)	CEP (yd)	CEP always zero
ALFA	2-KT	Yes	Yes	No	No	30,000	0	(*)	(*)	(*)	(*)	250	(*)
BRAVO	10-KT	Yes	Yes	No	No	30,000	0	10–25	250	20–150	500	250	(*)
CHARLIE	20-KT	Yes	Yes	Yes	Yes	30,000	0	10–25	250	20–150	500	250	Surface or underground
DELTA	50-KT	Yes	Yes	No	No	(*)	(*)	10–25	250	20–150	500	500	(*)
ECHO	75-KT	Yes	Yes	No	No	(*)	(*)	10–25	250	20–150	500	500	(*)
FOXTROT	100-KT	Yes	Yes	No	No	(*)	(*)	10–25	250	20–150	500	500	(*)
GOLF	200-KT	Yes	Yes	No	No	(*)	(*)	(*)	(*)	20–150	500	500	(*)
HOTEL	500-KT	Yes	Yes	No	No	(*)	(*)	(*)	(*)	20–150	500	1,000	(*)
INDIA	1-MT	No	Yes	Yes	No	(*)	(*)	(*)	(*)	20–150	1,000	1,000	(*)
JULIETT	5-MT	No	Yes	Yes	No	(*)	(*)	(*)	(*)	20–150	1,000	1,000	Surface only

[1] Use zero CEP for gun delivery except for troop safety purposes. Use 100-yard CEP for troop safety.
* No capability.

TABLE VII. *Damage Radii*
(distance in yards from GZ)

Weapon	Type of burst	Command post, field type, dug in	Damage to equipment requiring major repair effort[1]: Military vehicles	Tanks, artillery, armored vehicles and infantry weapons	Communication equipment	Destruction of buildings in built-up areas; obstacles in cities or forests	Supply and maintenance areas[1]	Port facilities	Major bridges	Start forest fires in fire season
ALFA	high air	1,400	negligible	negligible	negligible	850	negligible	400	negligible	750
2–KT	low air	1,100	550	200	600	600	300	300	250	800
BRAVO	high air	2,700	negligible	negligible	negligible	1,600	negligible	700	negligible	1,600
10–KT	low air	2,000	1,000	400	1,100	1,200	500	500	400	1,200
CHARLIE[2]	high air	3,000	negligible	negligible	negligible	1,800	negligible	800	negligible	2,700
20–KT	low air	2,300	1,100	450	1,300	1,350	600	600	500	2,800
	surface	2,300	1,100	450	1,300	1,350	600	600	500	2,800
	underground[3]	1,500	550	250	650	900	400	400	300	negligible
DELTA	high air	3,900	negligible	negligible	negligible	2,300	negligible	1,050	negligible	3,500
50–KT	low air	2,900	1,400	600	1,700	1,750	800	800	650	3,600
ECHO	high air	4,700	negligible	negligible	negligible	2,750	negligible	1,250	negligible	3,900
75–KT	low air	3,500	1,750	700	2,000	2,100	950	950	750	4,000
FOXTROT	high air	5,150	negligible	negligible	negligible	3,000	negligible	1,400	negligible	4,300
100–KT	low air	3,850	1,950	750	2,250	2,300	1,050	1,050	800	4,400
GOLF	high air	6,500	negligible	negligible	negligible	3,850	negligible	1,750	negligible	7,000
200–KT	low air	4,850	2,450	950	2,800	2,900	1,300	1,300	950	7,200
HOTEL	high air	8,800	negligible	negligible	negligible	5,200	negligible	2,350	negligible	9,500
500–KT	low air	6,700	3,350	1,300	3,800	3,900	1,750	1,750	1,300	9,800
INDIA	low air	8,300	4,200	1,650	4,800	4,900	2,200	2,200	1,700	12,000
1–MT	surface	8,300	4,200	1,650	4,800	4,900	2,200	2,200	1,700	12,500
JULIETT[2]	low air	14,000	7,200	2,850	4,200	8,300	3,750	3,750	2,800	20,000
5–MT	surface	14,000	7,200	2,850	4,200	8,300	3,750	3,750	2,800	20,500

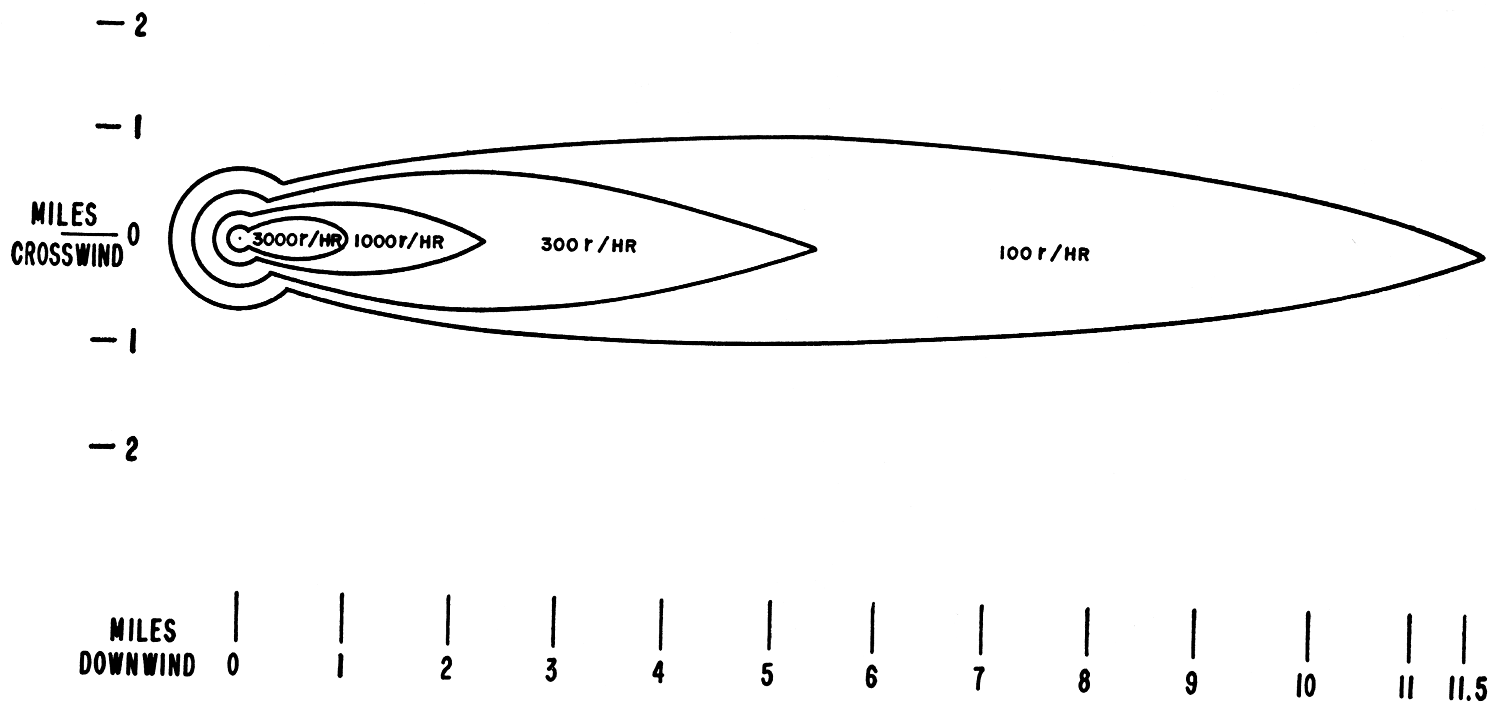
[1] For equipment or materiel dug in, use damage radii equal to one-half of those given above.
[2] For prepositioned weapons.
a. For CHARLIE weapon use underground burst data if depth of burst is greater than 25 feet; use surface burst data in all other cases.
b. Use surface burst data for JULIETT weapon.
[3] Underground burst is assumed to be at 50 feet depth.



NOTES: 1. Based on 15-knot scaling wind, dose rates normalized to 1 hour after detonation.

2. Total dose at any given point may be determined by considering the time fallout arrives (entry time) stay time and dose rate at 1 hour at any given point. Figure 3 may be used in making any such determination.

Figure 9. Fallout from a high-yield surface-burst weapon 15-knot scaling wind, dose rates normalized to one hour detonation.



NOTES: 1. BASED ON 15-KNOT SCALING WIND, DOSE RATES NORMALIZED TO 1 HOUR AFTER DETONATION.

2. TOTAL DOSE AT ANY GIVEN POINT MAY BE DETERMINED BY STAY TIME AND DOSE RATE AT THAT POINT. FIGURE 3 MAY BE USED IN MAKING ANY SUCH DETERMINATION.

Figure 10. Fallout from a low-yield surface-burst weapon.

FM 101-31-3

DEPARTMENT OF THE ARMY FIELD MANUAL

STAFF OFFICERS FIELD MANUAL

NUCLEAR WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY
FEBRUARY 1963

FIELD MANUAL
No 101-31-3

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., 1 February 1963

NUCLEAR WEAPONS EMPLOYMENT

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* This manual together with FM 101-31-1, 1 February 1963, and FM 101-31-2, 1 February 1963, supersedes FM 101-31, 20 July 1959, including C 1, 29 June 1961; FM 101-31 Modified, 15 September 1960; DA Pam 39-1, 20 May 1959; and DA TC 101-1, 8 December 1958, including C 2, 14 June 1960.

TABLE OF MAX R_T and MAX R_D (See notes.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
System	Range (m)		Yield	Exposed personnel targets				Protected personnel targets				Wheeled military vehicle targets		Tanks and arty targets	
				Prompt		Delayed		Prompt		Delayed					
	Min	Max	(KT)	$R_{T_{max}}$	$R_{D_{max}}$	$R_{T_{max}}$	$R_{D_{max}}$	$R_{T_{max}}$	$R_{D_{max}}$	$R_{T_{max}}$	$R_{D_{max}}$	$R_{T_{max}}$	$R_{D_{max}}$	$R_{T_{max}}$	$R_{D_{max}}$
Short-range cannon	2,000	10,000	0.5	700	425	1,000	675	500	300	800	500	300	200	175	125
			1	900	575	1,200	775	650	400	1,000	575	400	250	250	150
Medium-range cannon	2,000	20,000	1	900	575	1,200	775	650	400	1,000	575	400	250	250	150
			2	1,000	625	1,400	900	700	450	1,100	675	550	350	325	200
Long-range cannon	3,000	30,000	2	1,000	625	1,400	875	700	450	1,100	675	550	350	325	200
			5	1,200	800	1,600	1,050	1,000	625	1,300	825	800	500	450	300
			10	1,400	875	1,800	1,175	1,100	700	1,400	925	1,100	650	600	375
			20	1,800	1,250	2,000	1,250	1,200	800	1,600	1,025	1,400	850	800	500
			50	2,800	1,650	2,800	1,650	1,400	925	2,000	1,175	2,000	1,225	1,200	750
Small free rocket	3,000	25,000	0.5	700	425	1,000	675	500	300	800	500	300	175	125	100
			1	900	575	1,200	775	700	400	1,000	600	400	225	200	125
			2	1,000	625	1,400	900	700	475	1,100	675	550	325	300	150
			5	1,200	800	1,600	1,050	1,000	675	1,400	825	800	500	450	275
			10	1,400	900	2,000	1,175	1,200	700	1,400	925	1,100	650	600	375
Large free rocket	7,000	40,000	5	1,200	800	1,600	1,050	1,000	625	1,400	825	700	400	350	225
			10	1,400	900	2,000	1,175	1,200	700	1,400	925	1,000	575	500	300
			20	1,800	1,150	2,000	1,250	1,200	800	1,600	1,025	1,300	800	700	400
			50	2,800	1,650	2,800	1,650	1,600	925	2,000	1,175	2,000	1,225	1,100	625
			100	3,600	2,175	3,600	2,175	1,600	1,075	2,000	1,300	2,800	1,625	1,600	925
Light guided missile	10,000	50,000	0.5	700	425	1,100	675	500	200	800	500	200	125	50	100
			1	900	575	1,200	775	700	400	1,000	600	250	175	150	125
			2	1,000	625	1,400	900	700	475	1,100	675	500	250	200	150
			5	1,200	800	1,600	1,050	1,000	625	1,400	825	800	425	350	225
			10	1,400	900	2,000	1,175	1,200	700	1,400	925	1,000	600	500	300
			20	1,800	1,150	2,000	1,250	1,200	800	1,600	1,025	1,400	825	800	400
Medium guided missile	50,000	150,000	5	1,200	800	1,600	1,050	900	625	1,200	825	0	325	0	225
			10	1,400	900	1,800	1,175	1,000	700	1,400	925	800	500	0	300
			20	1,800	1,125	2,000	1,250	1,200	800	1,600	1,025	1,200	750	0	400
			50	2,800	1,650	2,800	1,650	1,400	925	1,800	1,175	2,000	1,150	900	550
			100	3,600	2,175	3,600	2,175	1,600	1,075	2,000	1,300	2,400	1,575	1,400	750
			200	4,800	2,875	4,800	2,875	1,800	1,150	2,400	1,450	3,200	2,025	1,600	975
			500	6,800	4,150	6,800	4,150	2,800	1,675	2,800	1,675	4,800	3,000	2,400	1,400
Heavy guided missile	50,000	300,000	200	4,800	2,875	4,800	2,875	1,600	1,150	2,000	1,450	2,800	1,725	1,000	975
			500	6,400	4,150	6,400	4,150	2,400	1,675	2,400	1,675	4,400	2,725	2,000	1,400
			1,000	8,800	5,475	8,800	5,475	3,200	2,100	3,200	2,100	6,400	3,750	2,800	1,850
			2,000	12,000	7,225	12,000	7,225	4,400	2,650	4,400	2,650	8,000	5,100	4,000	2,450
			5,000	16,000	10,425	16,000	10,425	6,000	3,600	6,000	3,600	12,400	7,575	6,400	3,650
Fighter	N/A	800 KM	5	1,200	800	1,600	1,050	1,000	625	1,300	825	600	325	150	225
			10	1,400	900	2,000	1,175	1,100	700	1,400	925	900	500	400	300
			20	1,800	1,125	2,000	1,250	1,200	800	1,600	1,025	1,200	750	600	400
			50	2,800	1,650	2,800	1,650	1,600	925	2,000	1,175	2,000	1,150	1,000	550
			100	3,600	2,175	3,600	2,175	1,600	1,075	2,000	1,300	2,600	1,575	1,400	750
			200	4,600	2,875	4,600	2,875	1,800	1,150	2,400	1,450	3,200	2,025	1,600	975
			500	6,600	4,150	6,600	4,150	2,800	1,675	2,800	1,675	5,200	3,000	2,600	1,400
			1,000	9,000	5,475	9,000	5,475	3,600	2,100	3,600	2,100	6,800	4,025	3,600	2,075
Tactical Bomber	N/A	1,200 KM	100	3,600	2,150	3,600	2,150	1,600	1,075	2,000	1,300	2,400	1,325	1,000	750
			200	4,800	2,875	4,800	2,875	1,600	1,150	2,400	1,450	3,200	1,725	1,400	975
			500	6,400	4,150	6,400	4,150	2,800	1,675	2,800	1,675	4,800	2,725	2,200	1,400
			1,000	8,800	5,475	8,800	5,475	3,600	2,100	3,600	2,100	6,000	3,750	3,000	1,850
			2,000	12,000	7,225	12,000	7,225	4,000	2,650	4,000	2,650	8,400	5,100	4,000	2,450
			5,000	16,000	10,425	16,000	10,425	6,000	3,600	6,000	3,600	13,200	7,575	6,600	3,650
Strategic Bomber	N/A	2,000 KM	1,000	8,000	5,475	8,000	5,475	2,400	2,100	2,400	2,100	5,600	2,975	1,600	1,850
			2,000	12,000	7,225	12,000	7,225	3,600	2,650	3,600	2,650	8,000	4,450	3,200	2,450
			5,000	16,000	10,425	16,000	10,425	5,000	3,600	5,000	3,600	12,000	6,950	5,000	3,525

NOTES:
1. All HOB options considered.
2. $R_{T_{max}}$ is largest target radius with average coverage of 0.4.
3. $R_{D_{max}}$ is largest probable minimum R_D tabulated.

Figure il.

ATOMIC DEMOLITION MUNITIONS
on the surface

SEVERE DAMAGE RADII—METERS

Materiel classification	*Yield–KT*					
	ALFA/ .5	*BRAVO/ 1*	*DELTA/ 5*	*ECHO/ 10*	*GOLF/ 50*	*HOTEL/ 100*
Tunnels and mines Heavy masonry or concrete dams and bridges	50	50	125	175	225	300
Tanks and artillery Locomotives Supply depots Engineer earthmoving equip Field fortifications	75	100	175	250	450	600
Engineer truck-mounted equip Earth-covered surface shelters Blast-resistant reinforced concrete bldgs	100	100	200	250	400	525
Military vehicles Railroad cars Communications equip Truss and floating bridges Monumental-type multistory wall-bearing bldgs Heavy steel frame industrial bldgs Multistory, reinforced concrete frame bldgs	150	200	375	500	950	1,250
Oil storage tanks Multistory, reinforced concrete bldgs (small window area) Multistory, steel frame office bldgs Light steel frame industrial bldgs	250	300	475	650	1,125	1,425
Multistory, wall-bearing bldgs (apt house type) Parked combat aircraft	375	450	800	1,000	1,700	2,125
Wood frame bldgs	375	650	1,050	1,325	2,275	2,875

Figure 12.1.

MODERATE DAMAGE RADII—METERS

Materiel classification	*Yield–KT*					
	ALFA/ .5	*BRAVO/ 1*	*DELTA/ 5*	*ECHO/ 10*	*GOLF/ 50*	*HOTEL/ 100*
Tanks and artillery Field fortifications	100	125	225	300	550	750
Earthmoving and truck-mounted engr equip Locomotives Military vehicles Earth covered surface shelters	125	175	325	450	850	1,100
Railroad cars Blast resistant reinforced concrete bldgs Truss and floating bridges	175	200	375	500	1,000	1,300
Heavy steel frame industrial bldgs Multistory, reinforced concrete frame bldgs Monumental-type multistory wall-bearing bldgs Multistory, steel frame office bldgs Light steel frame industrial bldgs	250	350	625	800	1,475	1,750
Multistory, reinforced concrete bldgs (small window area) Oil storage tanks Parked combat aircraft	475	600	1,000	1,275	2,175	2,750
Multistory, wall-bearing bldgs (apt house-type)	525	650	1,125	1,450	2,325	3,100
Wood frame bldgs	850	1,000	1,675	2,125	3,700	4,650

Figure 12.2.

CRATER DIMENSIONS (See note.)

Yield KT	*Approx crater dimensions for various soil types—meters*							
	Soft rock (dry soil or soft rock)		*Hard rock (granite and sandstone)*		*Saturated soil (water slowly fills crater)*		*Saturated soil (water rapidly fills crater)*	
	Radius	*Depth*	*Radius*	*Depth*	*Radius*	*Depth*	*Radius*	*Depth*
ALFA/.5	16	6	13	5	24	8	31	4
BRAVO/1	20	7	16	6	30	10	39	5
DELTA/5	34	10	27	8	50	15	67	7
ECHO/10	42	12	34	10	63	18	84	8
GOLF/50	72	17	58	14	108	26	144	12
HOTEL/100	91	21	73	17	136	31	182	15

NOTE: Based on contact surface burst, for more detailed analysis, see engineer element.

Figure 12.3.

CRATER DIMENSIONS SUBSURFACE BURSTS (see note)

Yield KT	Approximate crater dimensions for dry soil or soft rock		
	Depth of Burial	Crater Radius	Crater Depth
Alfa/.5	47	46	16
Bravo/1	58	57	19
Delta/5	93	91	31
Echo/10	114	112	38
Golf/50	183	180	61
Hotel/100	225	221	75

NOTE: At the depths of burial indicated, fallout is reduced to one hundredth of that from a contact surface burst.

Figure 12.4

CASUALTY RADII—METERS

Yield KT	*Exposed Personnel*		*Protected Personnel*	
	Prompt	*Delayed*	*Prompt*	*Delayed*
ALFA/.5	425	675	300	500
BRAVO/1	575	775	400	600
DELTA/5	800	1,050	625	825
ECHO/10	900	1,175	700	925
GOLF/50	1,300	1,475	925	1,175
HOTEL/100	1,725	1,725	1,075	1,300

Figure 12.5

FIRE AREAS (See note.)

Yield KT	*Expected radii for ignition of wildland fuels during fire season—meters*							
	Dry climate (25 percent relative humidity)				*Damp climate (75 percent relative humidity)*			
	Class I	*Class II*	*Class III*	*Class IV*	*Class I*	*Class II*	*Class III*	*Class IV*
ALFA/.5	500	500	400	400	500	500	400	400
BRAVO/1	700	600	500	500	600	600	500	400
DELTA/5	1,200	1,100	1,000	800	1,100	1,100	900	700
ECHO/10	1,500	1,400	1,300	1,100	1,400	1,400	1,200	900
GOLF/50	2,800	2,600	2,300	2,000	2,600	2,600	2,200	1,600
HOTEL/100	3,500	3,200	3,000	2,500	3,200	3,200	2,800	2,100

NOTE: For description of fuel classes, see FM 101-31-1, app. III, annex F.

Figure 12.6

DEPARTMENT OF THE ARMY FIELD MANUAL

MARINE CORPS FLEET MARINE FORCE MANUAL

FM 101-31-1
FMFM 11-4

STAFF OFFICERS' FIELD MANUAL
NUCLEAR WEAPONS EMPLOYMENT
DOCTRINE AND PROCEDURES

DEPARTMENTS OF THE ARMY AND THE NAVY
FEBRUARY 1968

FIELD MANUAL No. 101-31-1
FLEET MARINE FORCE MANUAL No. 11-4

DEPARTMENTS OF THE ARMY AND THE NAVY
WASHINGTON, D.C., *15 February 1968*

STAFF OFFICERS' FIELD MANUAL
NUCLEAR WEAPONS EMPLOYMENT
DOCTRINE AND PROCEDURES

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*This manual supersedes FM 101-31-1, 1 February 1963, including all changes.

age on the governing casualty-producing effect. When a weapon is employed, contingent effects, such as induced contamination, some probability of fallout, smoke, fire tree blowdown, and damage to industrial or urban areas, are considered. These contingent effects may be considered as a bonus or they may be unacceptable from an operational standpoint. In either event, the commander must be informed of their existence.

2–25. Arctic Environment and Extreme Cold

a. General. Nuclear weapon effects are altered by ice, snow, high winds, and low temperatures. General knowledge of the alterations to individual effects is essential so that sound operational decisions may be made.

b. Blast.

(1) *Effect of low temperatures on blast radii.* At temperatures about −45° C (−50° F), damage radii for materiel targets such as tanks, artillery, and military vehicles can increase by as much as 20 percent. If the temperature in the target area is known to be −45° C (−50° F) or colder, the validity of the estimate of damage might be increased somewhat by the inclusion of a 20-percent increase in the radii of effect for *drag-type targets*.

(2) *Surface reflectivity.* As indicated in paragraph 2–8*b*, reflecting surfaces, such as ice, snow, and water, increase the distance to which given static overpressures extend and decrease the distance to which given dynamic pressures extend. Muskeg and tundra decrease the distances to which given overpressures extend, and probably increase the distances to which given dynamic pressures extend. Areas of extremely irregular and broken icecaps, even though ice and snow, affect blast waves in a manner similar to muskeg and tundra. The effects of surface reflectivity are not considered in target analysis.

(3) *Contingent effects.* The cratering effect in ice and frozen soil is similar to the cratering effect in solid rock, however the crater size will probably be larger than that in rock. Crater dimensions in soil covered with deep snow are reduced.

(4) *Trafficability.* The following considerations affect the planning of movements:

(*a*) Shock of blast disturbance of permafrost may reduce trafficability.

(*b*) Nuclear weapon effects may interfere with movement over frozen waterways and, in the spring, cause a spring breakup.

(*c*) Nuclear weapon effects may produce avalanches in mountainous areas in appropriate seasons.

c. Thermal. While thermal effects normally are not considered in selecting the governing effect, a significant adjustment may be required in troop safety distances in the arctic.

(1) In conditions of extreme reflectivity (e.g., snow, ice, clouds), coupled with good visibility, the minimum safe distances (para 3–7 and 4–6) for unwarned, exposed and for warned, exposed personnel are increased by 50 percent.

(2) There will be some increase in the numbers of unwarned personnel suffering a loss of visual acuity, particularly at night.

(3) Because of the materials habitually used for clothing, personnel in the arctic environment may be less vulnerable to thermal effects. In addition, the cold temperatures reduce thermal effects to most materials. A frost covering on combustible materials reduces their susceptibility to thermal damage. Surface fires in dry tundra grasses may occur.

d. Nuclear Radiation.

(1) At very low temperatures, the atmospheric density increases to such an

extent that as much as a 25-percent reduction can be expected in the distances to which significant levels of nuclear radiation extend. If the temperature in the target area is known to be $-45°$ C ($-50°$ F) or colder, the estimate of casualties among protected personnel is more valid if the radius of damage for casualties, due to radiation, is reduced by 25 percent.

(2) The seasonal occurrence of extended periods of high winds in arctic areas may greatly extend fallout areas. A corresponding reduction of dose rates close to the ground zero may be expected as a result of the increased distribution. Further, falling or wind-driven snow may create areas of high concentration. Associated with the high concentration, winds may be expected to clear effectively some areas of fallout contamination.

(3) Where the earth's surface is covered with ice or snow, there is some reduction in the induced radiation activity in the underlying soil. A detonation over a thick ice and/or snow cover could result in essentially no significant induced radiation.

(4) Large, poorly drained areas and frozen soil of low permeability limit the natural flushing of radioactive material.

e. Other Considerations.

(1) The time required for subsurface shelter construction and the increased use of above-surface shelters generally increase the vulnerability of troops in the field to nuclear weapon effects. When shelters are constructed underground, they usually are more resistant to weapon effects than is similar construction in temperate climates. However, because frozen soil and water are excellent transmitters of ground shock, these underground structures are more susceptible to damage than similar structures in temperate climates.

(2) Because logistical problems are greatly increased in the arctic, most types of supply are critical. Loss of supplies because of nuclear detonations will have a greater impact on arctic operations than will a similar loss in nonarctic areas.

(3) The increased susceptibility of personnel to injury, with coincident difficulties of medical care, enhances the effects of a nuclear detonation in arctic operations.

2–26. High-Altitude Effects

As described in paragraph 2–20, the decreasing air density associated with increasing altitude provides a burst environment for nuclear weapons that can greatly alter effects. The amount of thermal radiation received by an aircraft varies widely with atmospheric conditions, orientation of the aircraft with respect to the burst, the ground-reflecting surfaces, and the clouds. Scatter and reflection may result in an aircraft receiving two or three times the thermal radiation received by a target on the ground. Conversely, when a heavy cloud layer is between the burst and the aircraft, the thermal radiation received may be negligible. Nuclear radiation is propagated to greater ranges at higher altitudes. Blast effects are decreased due to the decreased density of the surrounding medium. Nuclear bursts at high and extremely high altitudes also cause considerable problems with electromagnetic wave propagation types of communications (see DA Pam 39–3).

2–27. Validity of Effects Data

As discussed in paragraph 2–3, nuclear weapon testing has produced the effects data on which target analyses are based. Although TM 23–200 presents the validity factors associated with the data for each effect, the validity of effects data is not considered in the target analysis procedures described in chapter 3, in appendix B, and in tables in this manual. The target analyst should realize that errors in effects data accuracy exist and that

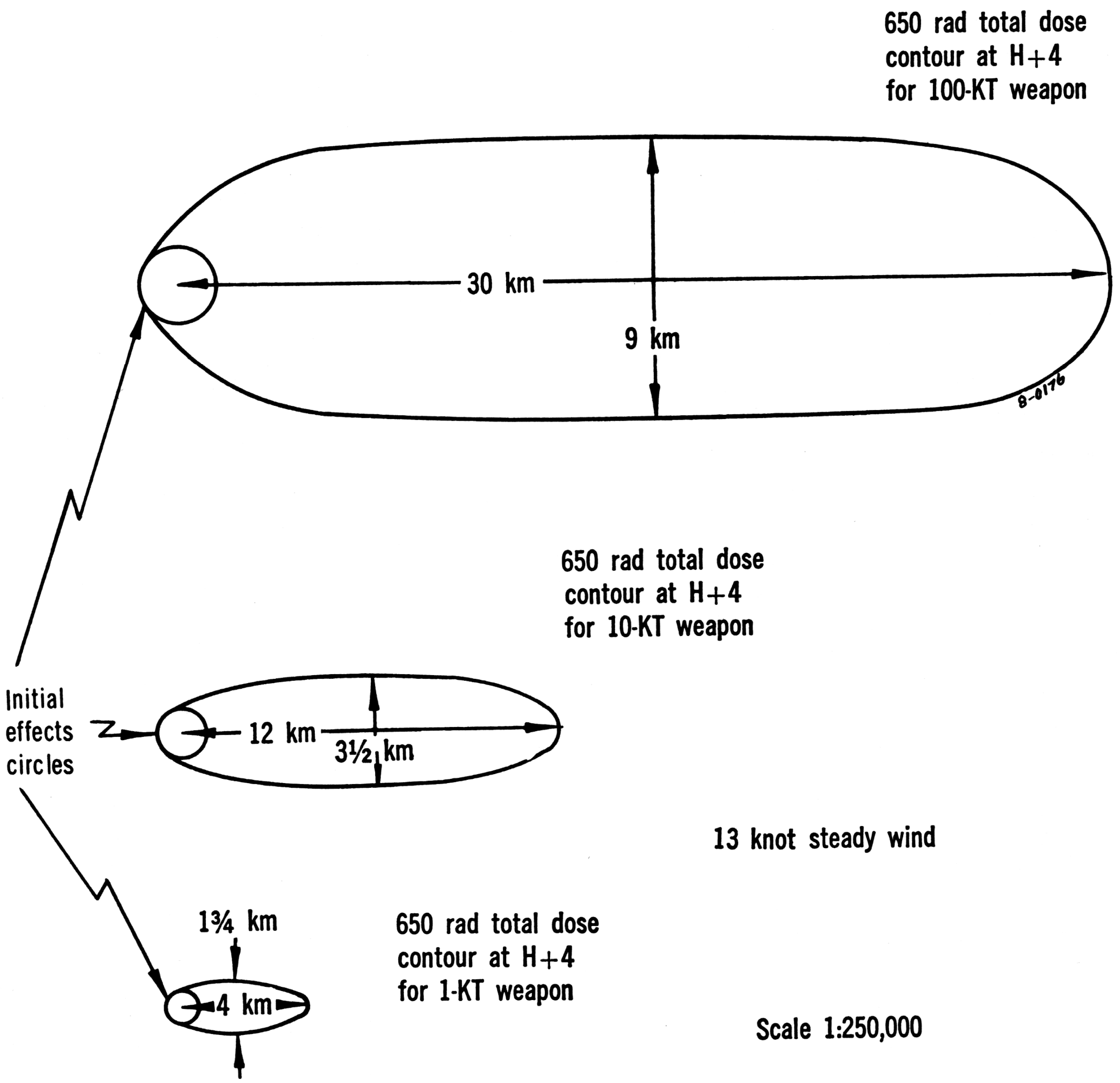

Figure 4-6. Comparison of initial effects and residual effects from 100-, 10-, and 1-kiloton surface bursts.

(*a*) The commander may decide that a suspected target is so important that he must attack it even though friendly intelligence agencies may not have been able to collect significant information on the target.

(*b*) Conversely, the commander may decide that a target is not of sufficient importance to warrant attack unless there is considerable certainty that the attack will be remunerative. In this respect, combat intelligence will seldom have the capability to provide complete target information. *Delay of nuclear attacks until detailed intelligence is developed may impede the effectiveness of the attack.* On the other hand, engagement of a target without some indication of its characteristics may cause an unwarranted waste of combat power.

b. Once targets have been evaluated and given a priority for attack, the *commander* determines whether to engage them with nuclear fires, nonnuclear fires, maneuver

may occur throughout the pattern because of winds or rain.

d. The total radiation dose absorbed by an individual is a function of radiation intensity, exposure time, and protection.

e. Residual radiation is absorbed or reflected in the same manner as prompt gamma radiation. See paragraph 2–21*b* for shielding considerations.

f. FM 3–12 provides procedures to compute permissible exposure times and total doses in fallout areas. The M1 radiac calculator can also be used to compute total doses and exposure times in single weapon fallout areas.

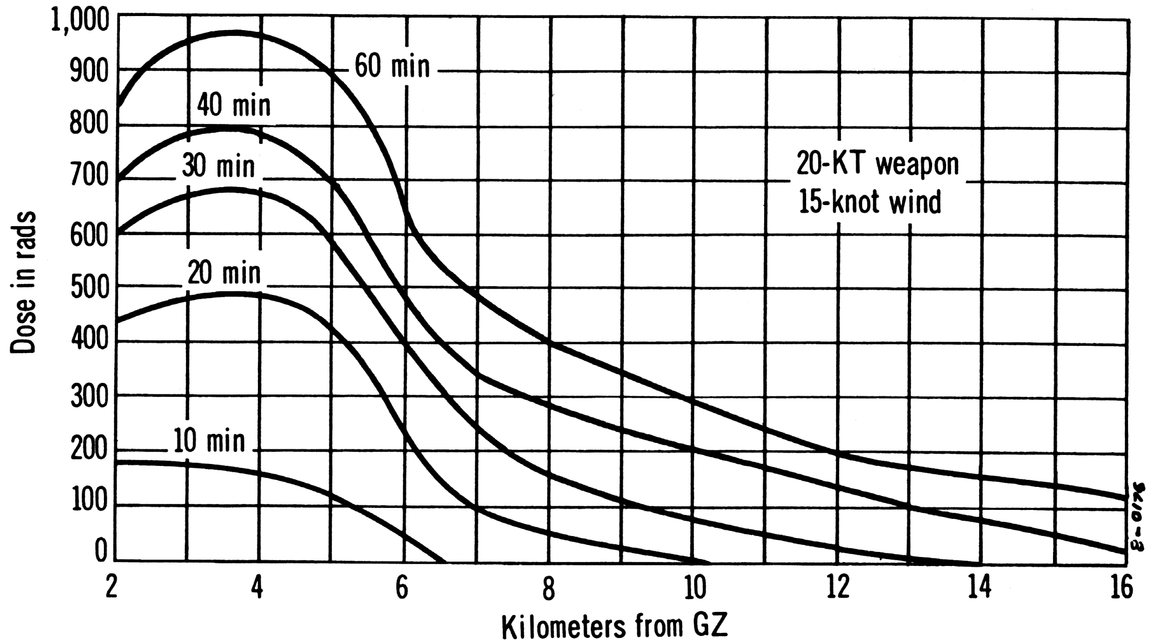

Figure 5–1. Total dose variation as a function of time after bursts and distance from the burst.

5–4. Prediction of Fallout Areas

(This paragraph is based on STANAG No. 2103.)

a. A tactical fallout prediction system must be a compromise between speed and simplicity, on the one hand; and the time-consuming complexity that increases accuracy, on the other. The present U.S. Army method of predicting fallout gives only a warning sector, somewhere within which most of the fallout is expected to occur.

b. The U.S. Army and U.S. Marine Corps method of fallout prediction is explained in TM 3–210. The prediction results in portrayal of an area that is expected to contain most of the significant fallout. A detailed prediction is prepared in the tactical operations center, based on the best available weather and weapon data. Brigade and lower units use the M5 fallout predictor and effective wind message to estimate the hazard area; the M5 predictor is applied using less precise data. Both predictions present a *graphical* portrayal of the expected hazard. The hazard area is subdivided into—

(1) An area within which countermeasures may have to be taken immediately (divided into two separately defined sub-areas); and

(2) An area in which early, but not immediate, action may have to be taken to counter the threat of unacceptable doses.

c. The basic inaccuracies in fallout prediction permit this method to be used in depicting suspect areas for early monitoring and survey, as well as for planning movement of units, but *not as a basis for executing operational moves* (para 5–5*a*(1)). The method also permits prediction of the areas outside which

CHAPTER 6

PROTECTIVE MEASURES

Section I. GENERAL

6–1. General

a. This chapter considers those situations in which personnel and materiel are exposed to some degree of nuclear weapon effects against which protection can be provided in the field.

b. Training in protective measures to be taken and establishment of correct operating procedures prepare the individual soldier for survival on the nuclear battlefield. Neither the threat of nor the use of enemy nuclear weapons can be permitted to interfere with the accomplishment of assigned missions. Forces able to protect themselves from nuclear weapon effects can maintain their combat capability.

c. The degree of protection that an individual or a unit is able to achieve in a given situation is determined by the preparedness of the unit or the individual at the time of the nuclear burst. The preparedness of the unit or the individual is dependent on such factors as—

(1) Time and materials available for the individual to prepare shelter.

(2) Training of the individual in protective measures.

(3) Sound unit SOP.

d. General guidance on protective measures is presented in this chapter; *details* are available in other publications referenced in this chapter. Figure 6–1 shows doctrinal threshold figures regarding troop safety criteria.

6–2. Principles of Protection

The principles of protection include dispersion, shielding, minimization of the time of exposure, and radiological decontamination.

a. Dispersion.

(1) For a given weapon, the distance between the desired ground zero and friendly troops (and their degree of protection) determines the risk of damage to them (para 3–7). The distances between units and between elements within a unit are a measure of the unit's vulnerability to nuclear attack (para 3–11). The dispersion desired in any given situation is determined by evaluation of such factors as mission, terrain, enemy target acquisition and nuclear delivery capability, and friendly unit dispositions. Dispersal of friendly forces achieves dual benefits.

(*a*) A well-dispersed unit that moves only under the cover of darkness and observes rigid camouflage discipline is difficult to detect and to attack.

(*b*) Even if it is detected and attacked, the well-dispersed unit will suffer fewer casualties than if it were not dispersed.

(2) While dispersion is desirable to reduce the vulnerability to nuclear attack, sufficient troop density must be maintained to accomplish the mission. Acceptable degrees of dispersion cannot be specified for all situations. The commander on the scene determines the permissible dispersion for each situation, giving primary consideration to the accomplishment of the mission.

b. Shielding. Shielding consists of providing

<table>
<tr><th rowspan="2">EFFECT</th><th rowspan="2">RISK LEVEL</th><th colspan="3">VULNERABILITY CATEGORY</th></tr>
<tr><th colspan="2">UNWARNED EXPOSED</th><th>WARNED EXPOSED</th></tr>
<tr><td rowspan="3">BLAST (psi)</td><td>Negligible</td><td colspan="3">V_1, $ER_{2.5}$<table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>ΔP</td><td>/</td><td>6.5</td><td>4.2</td><td>2.8</td><td>1.9</td><td>1.25</td></tr><tr><td>ER</td><td>8</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr></table></td></tr>
<tr><td>Moderate</td><td colspan="3">$V_{2.5}$, ER_5<table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>ΔP</td><td>/</td><td>8</td><td>5.5</td><td>3.5</td><td>2.1</td><td>1.5</td></tr><tr><td>ER</td><td>8</td><td>/</td><td>/</td><td>/</td><td>/</td><td>/</td></tr></table></td></tr>
<tr><td>Emergency</td><td colspan="3">V_5<table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>ΔP</td><td>15</td><td>9.2</td><td>6</td><td>4</td><td>2.75</td><td>1.75</td></tr></table></td></tr>
<tr><td rowspan="3">THERMAL cal/cm ^{2}</td><td>Negligible</td><td colspan="2">$Q^{1B}_{2.5}$<table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>0.85</td><td>1.0</td><td>1.15</td><td>1.3</td><td>1.5</td><td>1.75</td></tr></table></td><td>$Q^{1Us}_{2.5}$<table><tr><td>W</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>3.6</td><td>4.5</td><td>6.3</td><td>8.8</td></tr></table></td></tr>
<tr><td>Moderate</td><td colspan="2">Q^{1B}_5<table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>.95</td><td>1.1</td><td>1.3</td><td>1.5</td><td>1.75</td><td>2.0</td></tr></table></td><td>Q^{1Us}_5<table><tr><td>W</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>4</td><td>5.2</td><td>7.2</td><td>10</td></tr></table></td></tr>
<tr><td>Emergency</td><td colspan="2">Q^{2B}_5<table><tr><td>W</td><td>0.01</td><td>0.1</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>1.5</td><td>1.7</td><td>1.9</td><td>2.2</td><td>2.9</td><td>4</td></tr></table></td><td>Q^{2Us}_5<table><tr><td>W</td><td>1</td><td>10</td><td>100</td><td>1000</td></tr><tr><td>Q</td><td>4.7</td><td>6.1</td><td>8.8</td><td>12.5</td></tr></table></td></tr>
<tr><td rowspan="3">NUCLEAR single shot</td><td>Negligible</td><td>RS-1
5 rad</td><td>RS-2
..</td><td>RS-3
..</td></tr>
<tr><td>Moderate</td><td>20 rad</td><td>5 rad</td><td>..</td></tr>
<tr><td>Emergency</td><td>50 rad</td><td>20 rad</td><td>5 rad</td></tr>
</table>

W = Yield in kilotons

ΔP = Incident overpressure

Q^{2Us} = Incident thermal flux-2° burns under summer uniform

Q^{1B} = Incident thermal flux-1° burns to bare skin

V = Translational impact injury to prone personnel

ER = Ear drum rupture

RS = Unit radiation exposure category

Subscripts to Q, V, and ER denote probable percent of command affected by specified level of effect.

Figure 6–1. Troop safety criteria.

individuals and equipment with physical protection to reduce weapon effects. The best protection is afforded by deep underground shelters. Such structures are expensive in time and materials; their construction on the battlefield usually is not feasible. Reliance is placed on hasty field fortifications, such as trenches, foxholes, emplacements, revetments, bunkers, and simplified underground shelters. Tanks provide considerable protection against the effects of a nuclear explosion. Armored personnel carriers provide considerable protection against blast and thermal effects and some protection against initial nuclear radiation. Tracked carriers also provide some protection against residual radiation. Wheeled vehicles provide no protection against blast or initial nuclear radiation. Vehicle tarpaulins provide considerable protection against thermal radiation. Sandbags on the beds of trucks provide some protection against residual radiation. See FM 101–31–2 and chapter 18, FM 101–31–3 for appropriate transmission factors.

c. Minimization of the Time of Exposure. Techniques for minimization of the time of exposure to radiation are discussed in chapter 5.

d. Radiological Decontamination. Radiological decontamination is the process of reducing to an acceptable level the hazard of radioactivity from residual contamination. Radioactive contaminants are fission products, fusion products, unfissioned active material, and matter in which radioactivity has been induced. Some methods of decontamination are surface cleansing or scraping, sealing, and disposal. Decontamination processes do not neutralize or destroy radioactivity. These processes seek to diffuse and dilute the contamination to a safe level. Individual decontamination measures reduce radiation hazards that would result from ingestion or inhalation of radioactive particles coming in contact with the skin and clothing. Area decontamination requires organization, supervision, and considerable time, effort, and materiel. Decontamination procedures are discussed in detail in TM 3–220.

Section II. INDIVIDUAL PROTECTIVE MEASURES

6–3. General

a. Paragraph 4–6 discusses a warning system that permits timely notification of intended friendly employment of nuclear weapons. This system is also used to warn friendly troops in the isolated cases when enemy nuclear weapon employment is known in advance. For friendly employment, adequate warning is required to allow the individual to achieve the degree of protection assumed in the target analysis leading to a given burst. In the case of possible enemy employment, each individual observes the best protective procedures that his situation permits (table 6–1).

b. Specific references that should be consulted for more detailed information pertaining to protective measures are FM 21–40 and FM 21–41.

6–4. Enemy Employment

a. Proper reaction to attack offers the individual some chance for survival and early continuation of his mission. All personnel are trained to react rapidly, as follows:

(1) If exposed, move no more than a few steps to seek shelter.

(2) Drop flat on the ground.

(3) Close eyes.

(4) Protect exposed skin surfaces.

(5) Remain prone until after the blast wave has passed or debris has stopped falling.

b. Enemy nuclear weapons are expected to be followed by attacks involving enemy infantry, armor, or both. Individuals and units prepare to repel enemy followup operations, which may be accompanied by conventional artillery fires and use of chemical and biological agents.

Table 6-1. Types and Degrees of Protection for Personnel Against Nuclear Weapons Effects

Type of protection	Degree of protection: Initial effects: Blast	Initial effects: Thermal	Initial effects: Initial radiation	Residual radiation: Induced	Residual radiation: Fallout
In the open	None	None to fair. Clothing protects against heat, depending on nature of material and number of layers. Air between layers of clothing provides insulation.	None	None	None.
Stone, brick, or concrete walls.	Fair, depending on material, thickness, and type of construction.	Excellent against direct rays. None against rays reflected to back side of wall.	Some from direct radiation. None from scattered radiation.	None	None.
Ditches, slit trenches.	Good, depending on orientation relative to the ground zero.	Good, depending on depth and orientation. Rays can be reflected to inside.	Good, depending on depth and orientation. Radiation can be scattered to inside.	None	None against entry of fallout particles. Fair against radiation from surrounding area. Decontamination of ditches is difficult.
Culverts	Good, depending on orientation relative to the ground zero, depth, and construction.	Excellent, depending on orientation. Rays can be reflected into openings.	Excellent, depending on orientation and depth. Radiation can be scattered into openings.	Good, depending on depth and closing of openings with earth, sandbags, and other material.	Good, provided openings are closed with earth or other material and continuous decontamination is practiced.
Ravines and gullies	Fair	Excellent against direct rays. Some thermal may be scattered.	Some from direct radiation. None from scattered radiation.	None to fair	None to fair.
Open foxholes and trenches.	Good	Excellent against direct rays. Thermal can be reflected into foxhole.	Excellent against direct radiation. None from scattered radiation.	Questionable. Degree of protection depends on removing radioactive soil from surrounding area and inside foxhole or trench.	Excellent, provided foxhole is covered with poncho, shelter half, or other material to exclude fallout and particles; decontamination is continuous after fallout is complete.

APPENDIX A

REFERENCES

A–1. Army Regulations

AR 40–14	Control and Recording Procedures, Occupational Exposure to Ionizing Radiation.
AR 50–2	Nuclear Weapon Accident and Incident Control (NAIC).
AR 55–203	Movement of Nuclear Weapons Components and Nuclear Weapons Material.
AR 95–55	Nuclear Weapon Jettison.
AR 220–58	Organization and Training for Chemical, Biological, and Radiological (CBR) Operations.
AR 320–5	Dictionary of United States Army Terms (Short Title: AD).
AR 320–50	Authorized Abbreviations and Brevity Codes.
(O) AR 700–65	Nuclear Weapons and Nuclear Weapons Material.

A–2. Field Manuals

FM 310	Employment of Chemical and Biological Agents.
(S) FM 3–10A	Employment of Biological Agents (U).
(C) FM 3–10B	Employment of Chemical Agents (U).
FM 3–12	Operational Aspects of Radiological Defense.
FM 3–15	Nuclear Accident Contamination Control.
FM 5–26	Employment of Atomic Demolition Munitions (ADM)
FM 6–20–1	Field Artillery Tactics.
FM 6–20–2	Field Artillery Techniques.
(S) FM 9–2A	Special Ammunition Logistical Data (Classified Data) (U).
FM 9–6–1 (Test)	Ammunition Service in the Theater of Operations TASTA–70.
FM 21–30	Military Symbols.
FM 21–40	Chemical, Biological, and Nuclear Defense.
FM 21–41	Soldier's Handbook for Defense Against Chemical and Biological Operations and Nuclear Warfare.
FM 31–10	Barriers and Denial Operations.
(S) FM 44–1A	U.S. Army Air Defense Employment (U).
FM 54–8 (Test)	The Administrative Support Theater Army TASTA–70.
FM 61–100	The Division.
(S) FM 101–31–2	Staff Officers' Field Manual; Nuclear Weapons Employment Effects Data (Classified) (U).
FM 101–31–3	Staff Officers' Field Manual; Nuclear Weapons Employment Effects Data (Unclassified).
FM 105–5	Maneuver Control.
(C) FM 105–6–1	Nuclear Play Calculator (U).
FM 105–6–2	Nuclear Play Calculator.

FM 105-6-3	Nuclear Play Calculator Aggressor.

A-3. Technical Manuals

TM 3-210	Fallout Prediction.
TM 3-220	Chemical, Biological, and Radiological (CBR) Decontamination.
TM 5-225	Radiological and Disaster Recovery at Fixed Military Installation.
TM 5-311	Military Protective Construction (Nuclear Warfare and Chemical and Biological Operations).
(C) TM 23-200	Capabilities of Nuclear Weapons (U).
TM 55-602	Movements of Special Freight.

A-4. Other Publications

DA Pam 39-3	Nuclear Weapons.
JCS Pub 1	Dictionary of United States Military Terms for Joint Usage (Short Title: JD).
TB 385-2	Nuclear Weapons Firefighting Procedures.
TB CML 92	Calculator Set, Nuclear M28.
TB CML 120	Area Predictor Radiological Fallout, M5.
TC 3-15	Prediction of Fallout from Atomic Demolition Munitions (ADM).

FM 100-30

NUCLEAR OPERATIONS

Headquarters, Department of the Army

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Field Manual
100-30

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 29 October 1996

NUCLEAR OPERATIONS

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PREFACE

In the past, Soviet-styled armored echeloned formations were the primary threat to the United States (US). In response to this threat the US designed and stockpiled tactical nuclear weapons. Today's threats consist of regional instabilities and the proliferation of weapons of mass destruction (WMD). However, the US, as well as many other nations, actively pursues a policy of nonproliferation. Despite this, the number of nations who have, or are developing, nuclear weapons continues to grow. Therefore, the US may some day find itself confronted by an opponent who possesses nuclear weapons. Because of the continuing reduction in the size of US military forces, the US could also find itself opposed by an overwhelming conventional threat. Either scenario could lead to the use of nuclear weapons. Therefore, the US must concern itself with countering the proliferation of weapons of mass destruction.

Despite the continuing drawdown of US military forces, the current national military strategy includes fighting and winning two near-simultaneous regional wars with conventional forces. Any US threat of employing nuclear weapons is to deter a potential adversary's use of such weapons. If deterrence fails. the goal is to end hostilities on terms acceptable, at the lowest level of conflict, to the US and its allies. However, the US unilaterally reserves the right to use nuclear weapons if necessary. Use would be restricted, of course, with tight limits on the area and time of use. This would allow the belligerent to recognize the "signal" of limited response and to react accordingly.

The Army describes battlefield nuclear warfare (BNW) in terms of being able to conduct continuous combat operations in a nuclear environment. The presence of any nuclear-capable system, before, during, or after nuclear-weapons employment by either friendly or enemy forces, creates a nuclear environment. The implications of their very presence creates the nuclear environment.

Before 1991, the US Army had custody of tactical nuclear weapons which were to be employed, on Presidential release, by organic Army field artillery units. In September 1991, the Presidential Nuclear Initiative (PNI) removed the organic nuclear responsibility from the US Army. Today the Army neither has custody of nuclear weapons nor do corps and divisions employ them. The US Air Force or the US Navy are now responsible for delivery of nuclear weapons in support of Army operations. The Army retains its role in nominating nuclear targets and is also responsible for nuclear force protection.

This manual establishes Army doctrine for operations in a nuclear environment and details the doctrine for integrating nuclear considerations into all other aspects of the battlefield. It also describes the Army's role in nominating targets at corps and above levels and protecting the force from the effects of nuclear weapons detonation.

Nuclear operations may occur at strategic, operational, and tactical levels of war. Nuclear employment in a theater of operations has theater strategic, operational, and tactical results; execution has national strategic implications. The corps' role is to function at either the tactical or operational levels of war. At the tactical level, the corps accomplishes missions as Field Manual (FM) 100-15 describes. At the operational level, when directed and augmented, the corps functions as either the Army force (ARFOR), the joint force land component command (JFLCC), or a joint task force (JTF). By viewing the corps in its many possible roles, the reader can also discern nuclear procedures for echelons above corps (EAC) and joint missions.

This manual can help educate and train commanders and staffs at corps and operational levels in nuclear operations and educate and train divisions in nuclear force protection. It is used with Joint Publications (JP) 3-12.1, 3 -12.2 (SRD), or 3-12.3, and serves as the bridge between joint and

DETERRENCE

Although the US military force's overriding mission is to deter war, especially nuclear war, the intent behind the 1991 Presidential Nuclear Initiative (PNI) was to enhance national security through arms reduction while preserving the capability to regenerate selected forces if required. Recent arms control agreements and unilateral initiatives provide for real reductions in the arsenals of nuclear powers. However, even with the most optimistic outlook, the sheer number of remaining weapons is formidable. An increasing number of potentially hostile states are developing or have the capability to develop weapons of mass destruction. Therefore, the US must maintain a modem, reliable, and fully capable strategic deterrent as its number one defense priority.

Deterrence is the product of a nation's military capabilities and that nation's willingness to use those capabilities. The US' policy is to terminate conflict at the lowest possible level of violence consistent with national and allied interests. The ability to conduct operational- and tactical-level nuclear activities enhances US deterrent policy.

The potential employment of nuclear weapons at theater level, when combined with the means and resolve to use them, makes the prospects of conflict more dangerous and the outcome more difficult to predict. The US' position is that it can achieve deterrence if any potential enemy believes the outcome of nuclear war to be so uncertain, and the conflict so debilitating, that he will have no incentive to initiate a nuclear attack. The resulting uncertainty reduces a potential aggressor's willingness to risk escalation by initiating conflict.

At the same time, a credible defensive capability, which would include the threat of employing nuclear weapons, could bolster the resolve of allies to resist an adversary's attempts at political coercion. For example, the US' capability of responding to biological and chemical attacks with nuclear weapons would likely reduce or eliminate such attacks.

Nuclear weapons contribute to but do not by themselves ensure deterrence. To have a credible nuclear deterrent requires a nation to have the means, the ability, and the will to employ nuclear weapons. The nation must also have—

- A reliable warning system.
- A modern nuclear force.
- The capability and flexibility to support a spectrum of response options.
- A deployable defensive system for theater protection.

The threat of nuclear escalation is a major concern in any military operation involving the armies of nuclear powers. Controlling escalation is essential to limiting a rational threat's incentive for nuclear response. Escalation control involves a careful selection of options to convey to the enemy that, although the US is capable of escalating operations to a higher level, it has deliberately withheld strikes.

The US views restraint in the use of nuclear weapons as an important way to control the escalation of warfare. Restraint provides leverage for a negotiated termination of military operations. However, the US cannot assume a potential enemy will view restraint in the same way, or that he will not employ weapons of mass destruction. Therefore, the US must be capable of deploying those forces necessary to defeat aggression, provide coercion, and bring the war to a speedy termination on terms favorable to the US and its allies. Commanders and staffs at all levels must continue to be familiar with nuclear-weapons effects, the actions required to minimize such effects, and the risks associated with using nuclear weapons.

THE THREAT

The Cold War era's definitive threats to American security were nuclear surprise attack and the possible invasion of Western Europe. The new threat is worldwide regional instability (including the possible regional use of nuclear weapons) coupled with the proliferation of weapons of mass destruction.

Developing countries as well as regional powers are gaining the ability to manufacture nuclear arsenals. The current threat from developing nations primarily consists of short- and intermediate-range ballistic and cruise missiles and aircraft capable of carrying nuclear weapons and other weapons of mass destruction. Other threats, such as terrorists groups, may also possess nuclear weapons.

A nation that has the capability of using ballistic or cruise missiles and high-speed aircraft to deliver weapons of mass destruction at extended ranges

significantly increases those weapons' effectiveness as instruments of terror. Such capability also enhances the possibility of conflict escalation beyond a hostile region's boundaries.

The use of, or the threat of using, weapons of mass destruction within a campaign or major operation can cause large-scale shifts in objectives, phases, and courses of action (COA). Nuclear weapons make it possible to drastically change the effective ratio of regional forces and equipment and to create conditions favorable to a threat's operations. Consequently, if a potential adversary is not successful conventionally, he might consider using weapons of mass destruction.

The most accepted enemy employment methodology to destroy critical targets is surprise. A potential enemy might try to destroy massed units and all other critical targets using various nuclear-weapons burst options (space bursts, air bursts, surface bursts, below-surface bursts). Such attacks might be single attacks or part of a group of massed nuclear strikes. Therefore, retaliation or escalation would result in the likelihood of nuclear use against friendly forces. Or, retaliation or escalation could be used in response to an enemy's first use of weapons of mass destruction.

One element of the commander's critical information requirements (CCIR) is determining if the theater threat is capable of using weapons of mass destruction. The answer dictates future command actions.

PROLIFERATION, NONPROLIFERATION, AND COUNTERPROLIFERATION

Proliferation is the process by which one nation after another comes into the possession of or attains the right to determine the employment of nuclear weapons, each potentially able to launch a nuclear attack upon another nation. Nonproliferation efforts focus on preventing the spread of missiles and weapons of mass destruction through arms and export controls beyond the scope of corps and EAC interest. Counterproliferation strategy focuses on military measures centering both on how to deter or discourage as well as how to defend and attack against the possible use of such weapons.

The Department of Defense's (DOD) counterproliferation initiative recognizes the goal of preventing proliferation of weapons of mass destruction and their associated delivery systems. It also recognizes that the US must continue to expand its efforts to protect forces, interests, and allies. The initiative has two fundamental goals:

- To strengthen DOD's contribution to governmentwide efforts to prevent, or diplomatically reverse, the acquisition of weapons of mass destruction.
- To protect US interests and forces (as those of its allies) from WMD effects by assuring that US forces have the equipment, doctrine, and intelligence needed to confront, if necessary, any future opponent who possesses weapons of mass destruction.

The Department of Defense marshals its unique technical, military, and intelligence expertise—

- To improve arms control compliance.
- To control exports.
- To inspect and monitor the movement of nuclear materials.
- To interdict shipments for inspection during crises.
- To strengthen the norms and incentives against WMD acquisition.

The Department of Defense's acquisition strategy in the areas of command, control, communications, and intelligence (C^3I), counterforce operations, active defense, and passive defense address the following critical counterproliferation challenges:

- Detecting and destroying WMD capabilities from production through storage to deployment.
- Conducting military operations in a WMD environment.
- Dealing with consequences of WMD use, including medical treatment, clean-up, and recovery.
- Coping with the diffusion of new technologies.

NOTE: This manual concerns the nuclear part of weapons of mass destruction.

Although nuclear weapons are an element of deterrence, potential regional adversaries might or might not understand the deterrence value of the

US' nuclear weapons. If the goals of promoting peace, deterring war, and resolving conflicts fail, deterrence fails. Therefore, fighting and terminating hostilities become paramount. United States doctrine assumes that if the potential foe is capable of using weapons of mass destruction, then US forces must act accordingly.

NUCLEAR FORCES

Nuclear-capable forces (Navy and Air Force) are instruments of national power in regional conflicts. They contribute to theater deterrence or provide a war-fighting option to the NCA.

Because the Army no longer has an organic nuclear capability, the Navy or Air Force will provide nuclear support. The Army can now only nominate nuclear targets, usually at no lower than the corps level. The division normally is limited to NBC protection activities.

The capability of the US to deploy nuclear forces into a theater significantly complicates the enemy's planning process. The alert status of nuclear forces is a function of the world situation at any given time and, thus, enhances their responsiveness.

LEADERSHIP

Battlefield stress in a nuclear environment will be higher than US forces have ever experienced. Only disciplined, well-trained, and physically fit units can function well in such an environment. Commanders who understand this and who provide soldiers with strong, positive leadership; good mental and physical preparation; and clear, comprehensive plans will ensure soldiers are in a better position to survive and win.

Units may have to operate with reduced mutual support and fire support, with degraded electronic communications abilities along extended lines of communications (LOC), and possibly without centralized control or continuous communications. Therefore, to improve command and control (C^2) leaders must work toward three general goals (which take on added importance in nuclear operations):

1. Instill an aggressiveness in their units that will transcend the shock and stress of the nuclear environment.
2. Train junior leaders to think and operate independently.
3. Develop small-unit cohesion.

Commanders and staffs must fully understand the potential of nuclear-weapons use by both an adversary and by a US joint force. They must also have a working knowledge of—

- Nuclear-weapons effects.
- Employment doctrine.
- Survivability measures necessary to preserve combat power.
- Medical requirements as a result of a nuclear explosion.
- The psychological impact of nuclear warfare on soldiers and units.

As commanders plan and fight successive battles involving actual or possible nuclear operations, they must continually assess their soldiers' psychological and physiological stresses. Commanders must emphasize situations in training, exercises, and leadership which will help soldiers accomplish their missions.

TRAINING

On a nuclear battlefield every soldier will confront new and strange circumstances and be under constant danger of attack. Nuclear weapons will quickly cause many casualties as well as intermediate and long-term radiation effects. Soldiers will be exposed to death and destruction of a magnitude far beyond imagination and may have to operate in widely dispersed, isolated, and semiindependent groups. Everyone must understand and practice survival and mitigation techniques. Such techniques will give soldiers direction and confidence in a confusing, frightening situation.

The large and sudden losses that a nuclear attack will cause will shock and confuse inadequately trained or psychologically unprepared troops. Reaction times will be slower, and the ability to respond to leadership and the desire to perform at peak proficiency may be degraded. The violence, stress, and confusion can easily divert attention from battlefield objectives. Extraordinary discipline and leadership are vital to overcoming distractions,

maintaining the mission's focus, and pressing the fight.

Training, the cornerstone of success, technically and psychologically prepares soldiers for the nuclear environment. Successful nuclear operations require expanded combat training that includes—

- Mitigation techniques against nuclear effects.
- Radiation monitoring.
- Decontamination techniques.
- Operations exploiting nuclear-weapons use.
- Recovering and regrouping after an attack.
- Handling mass casualties.
- Having to use degraded resources to accomplish the mission.
- Nominating nuclear targets.

Soldiers will fight as well or as poorly as they have been trained. Clear, concise policies and guidelines provide control and direction. Commanders must emphasize the fact that aggressive maneuver, even by relatively small units, will have a high probability of success in the confused aftermath of a nuclear attack.

NOTE: See FM 25-50 for in-depth discussions of these topics.

SUMMARY

This chapter describes the transition of joint nuclear doctrine to Army-oriented nuclear doctrine. A nuclear environment exists if either adversary in the conflict possesses nuclear capabilities. The levels of war clarify simultaneous activities Army forces conduct in the theater. Each level supports the next higher level of war.

The overall mission of military forces is to deter war—especially nuclear war. If deterrence fails, the US must be capable of deploying the forces necessary to defeat aggression, provide cohesion, and bring war to a speedy termination on terms favorable to the US and its allies.

The threat is worldwide regional instability (including possible use of nuclear weapons) coupled with the proliferation of weapons of mass destruction. Proliferation occurs when nations acquire and have the ability to use nuclear weapons against another nation. Nonproliferation activities attempt to prevent the spread of weapons of mass destruction. Counterproliferation centers on how to deter, defend, and attack against possible use of nuclear weapons.

In the event of either friendly or enemy nuclear-weapons use, commanders must provide soldiers with strong positive leadership, good mental and physical preparedness, and clear comprehensive plans. Positive leadership will ensure soldiers survive and win. Training is the cornerstone for success.

Enemy

Anticipating and planning against the effects of enemy nuclear-weapons use against friendly forces is critical to campaign design. Commanders must ask, "Does the enemy have nuclear capability?" If the answer is no, the question is moot. If the answer is yes, commanders must address issues such as dispersion, type, yield, delivery means, availability of weapons, doctrine, tactics, and the likelihood of use.

Troops

The number and type of troops available could greatly affect the tactical plan. Nuclear weapons can rapidly and decisively enhance combat power. Smaller forces possessing nuclear weapons can accomplish the mission of larger forces not possessing nuclear weapons. The unit's RES determines its fitness for duty. The lower the RES, the healthier the soldiers.

NOTE: See FM 3-3-1.

Terrain and Weather

Terrain and weather can affect nuclear-weapons operations and influence offensive maneuver. For example, tree blowdown in a heavily forested area would obstruct the forward movement of friendly forces.

Normally, tactical fallout will not be significant in a low air burst. However, weather conditions could cause rainout in the area of operations. Therefore, if rain or snow falls through a nuclear cloud, significant tactical fallout may occur. Rain and fog can also lessen the blast wave as it travels through dense air.

Time Available

Offensive actions become harder to conduct when the enemy has had time to organize his defense. The friendly commander can nominate nuclear weapons to effect surprise, prolong confusion, and sustain disorganization. Conversely, the nomination process can erode friendly units' available time because of the necessity of having to relay information and requests up through the chain of command and back down again.

CONDUCTING OFFENSIVE OPERATIONS

The commander plans and coordinates force movement in detail to avoid confusion and delay and to gain surprise. He concentrates his forces quickly, making maximum use of cover and concealment, signal security, and deception while avoiding or masking actions that would alert the enemy to the coming attack. He then conducts the attack rapidly and violently with concentrated firepower to disrupt enemy positions and hit deep in the enemy rear. Nuclear weapons can enhance and support such plans by providing—

- Destructive firepower. Nuclear weapons, even when limited, can help friendly forces cause great destruction of enemy positions with a minimum concentration of forces.
- Surprise. Because delivery of nuclear fires requires little visible unit preparation, surprise can be complete. However, OPSEC within the stockpile-to-target sequence is essential. Forces must avoid a great display of preparation before nuclear strikes to prevent the loss of surprise.
- Shock. Nuclear-weapons use disorganizes, demoralizes, and freezes enemy forces in place. However, these effects will only be temporary; exploitation must be immediate.
- Flexibility. As maneuver forces develop the situation, the commander can nominate nuclear weapons to develop a major operation. He might also substitute nuclear weapons for maneuver forces, allowing a smaller force to succeed in its attack against a stronger force.
- Obstacles. A nuclear weapon can alter terrain to create obstacles such as fallen trees, fires, craters, rubble, and radiation. This nearly instant creation of massive obstacles will allow a smaller force to succeed where a larger force might ordinarily be required. Creation of obstacles slows and canalizes counterattacks and denies terrain to the threat. But, like shock and surprise, obstacles are temporary. Conversely, obstacles can impede forward maneuver if the commander has not considered least-separation distances.

Nuclear weapons can provide the commander with a unique advantage. However, he equally

100-15 *Corps Operations.* This manual contains operational-level doctrine to corps commanders and staffs.

100-16 *Army Operational Support.*

100-17 *Mobilization, Deployment, Redeployment, Demobilization.*

Joint Publications (JP)

1-02 *Department of Defense Dictionary of Military and Associated Terms.*

3-12 *Doctrine for Joint Nuclear Operations.* This publication sets forth doctrine for the combatant commander to use for the conduct of joint nuclear operations. It guides the joint planning and employment of US nuclear forces.

3-12.1 *Doctrine for Joint Nonstrategic Nuclear Weapons Employment.* This publication provides guidance for nuclear-weapons employment. Doctrine and guidance apply to the commander of combatant commands, subordinate unified commands, joint task forces, and subordinate components of these commands.

3-12.2 (SRD) *Nuclear Weapons Employment and Effects Data* (U). This publication sets forth doctrine and selected TTP for joint operations and training. It is the accepted joint standard for nuclear target analysis, employment procedures, and the source for nuclear effects data.

3-12.3 *Nuclear Weapons Employment and Effects Data.*

Department of Defense Nuclear Agency Effects Manuals (DNA EM)

1 (SRD) Chapter 10 Electromagnetic Pulse.

Chapter 14 Effects of Personnel.

Chapter 15 Damage to Structures.

Chapter 17 Damage to Military Field Equipment.

Chapter 21 Damage to Missiles.

NOTE: DNA is now known as the Defense Special Weapons Agency (DWA).

RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand this publication.

Allied Tactical Publications (ATP)

35A *Land Force Tactical Doctrine.* This publication establishes common NATO doctrine for the use of land force commanders in military operations when NATO forces are placed under their command.

SOVIET MILITARY POWER

1986

DEPARTMENT OF DEFENSE

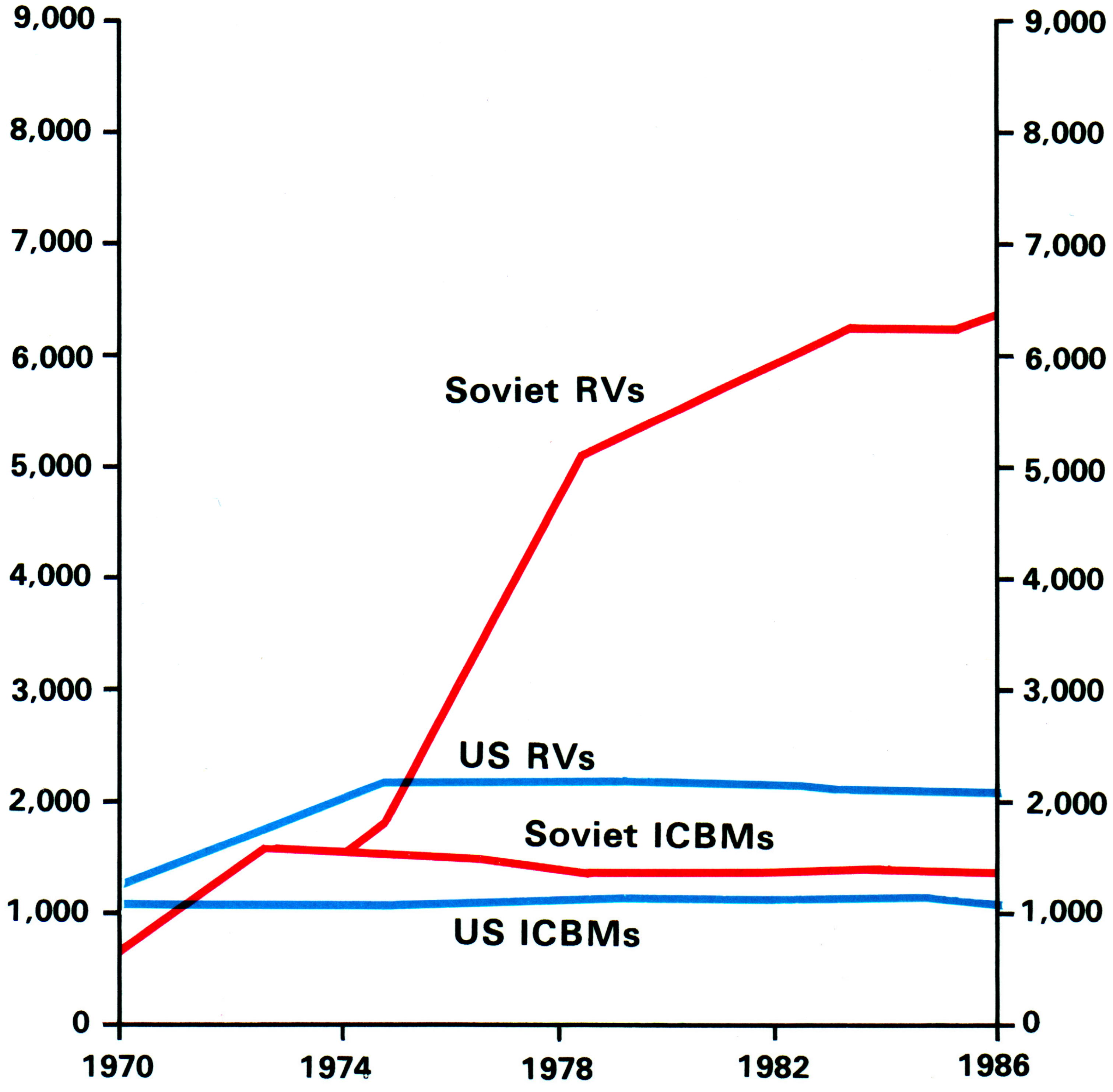
UNITED STATES OF AMERICA

SOVIET MILITARY POWER

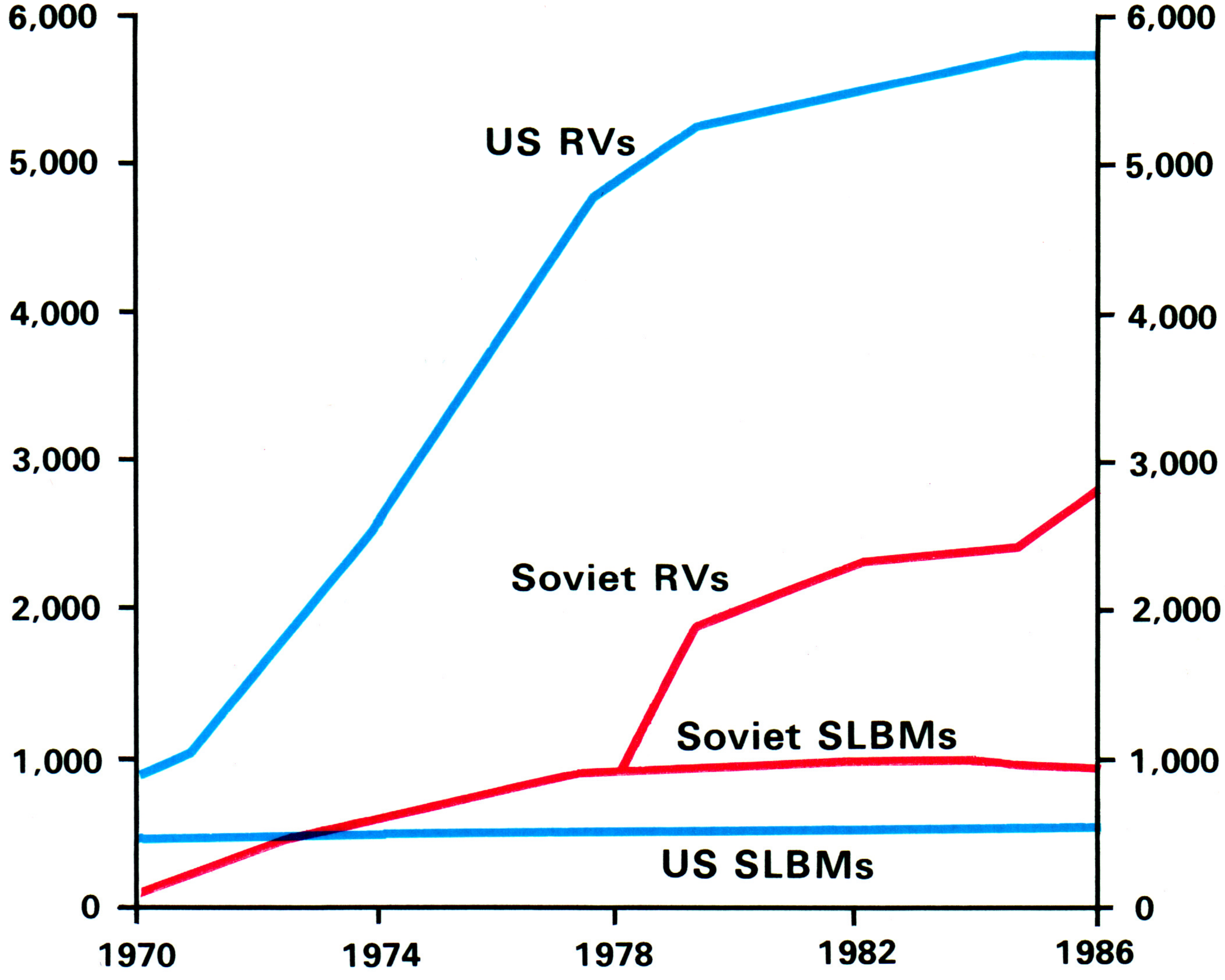
First Edition	September 1981
Second Edition	March 1983
Third Edition	April 1984
Fourth Edition	April 1985
Fifth Edition	March 1986

For sale by Superintendent of Documents, US Government Printing Office, Washington DC 20402

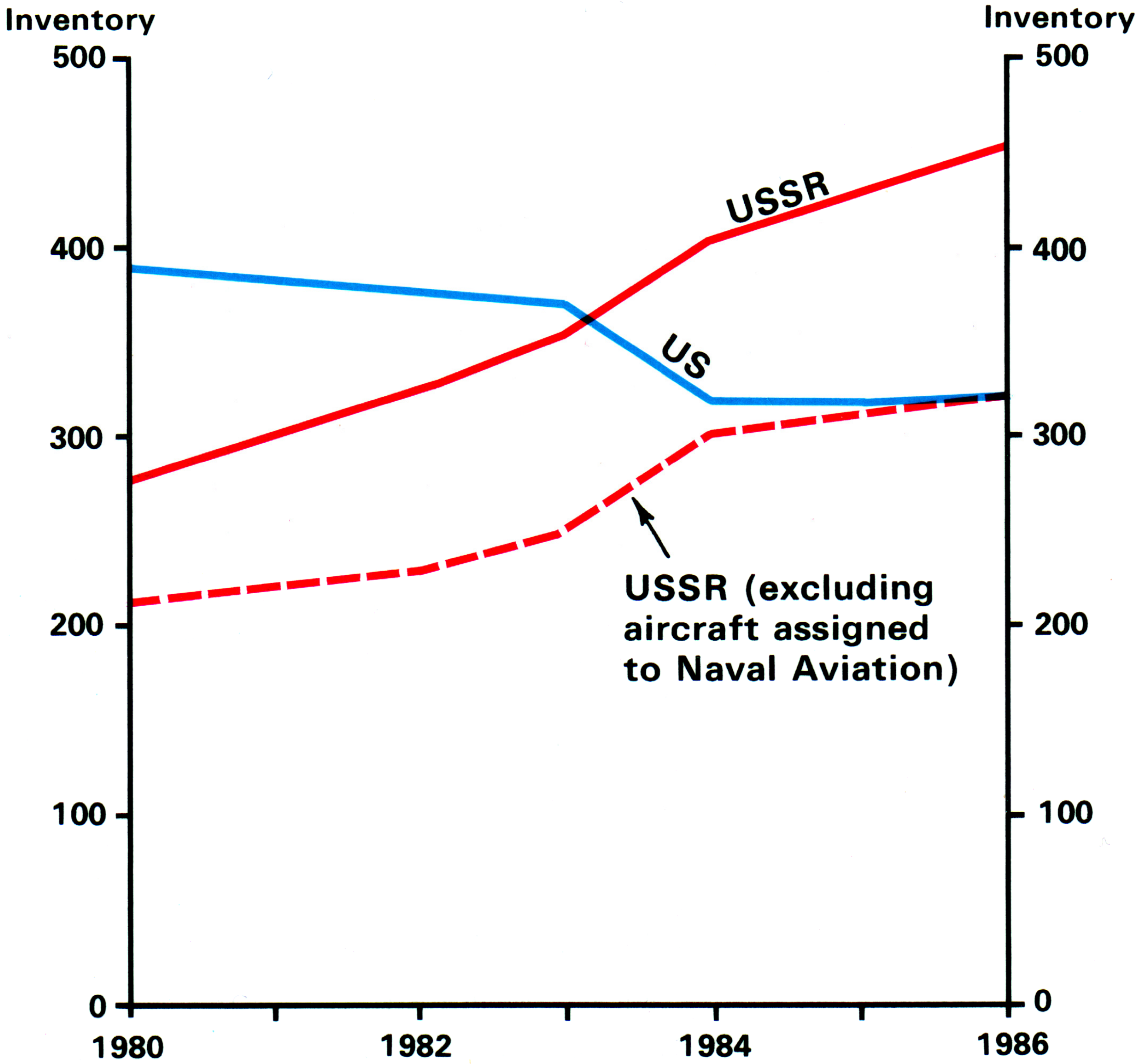
US and Soviet ICBM Launcher and Reentry Vehicle (RV) Deployment 1970-1986



US and Soviet SLBM Launcher and Reentry Vehicle (RV) Deployment 1970-1986

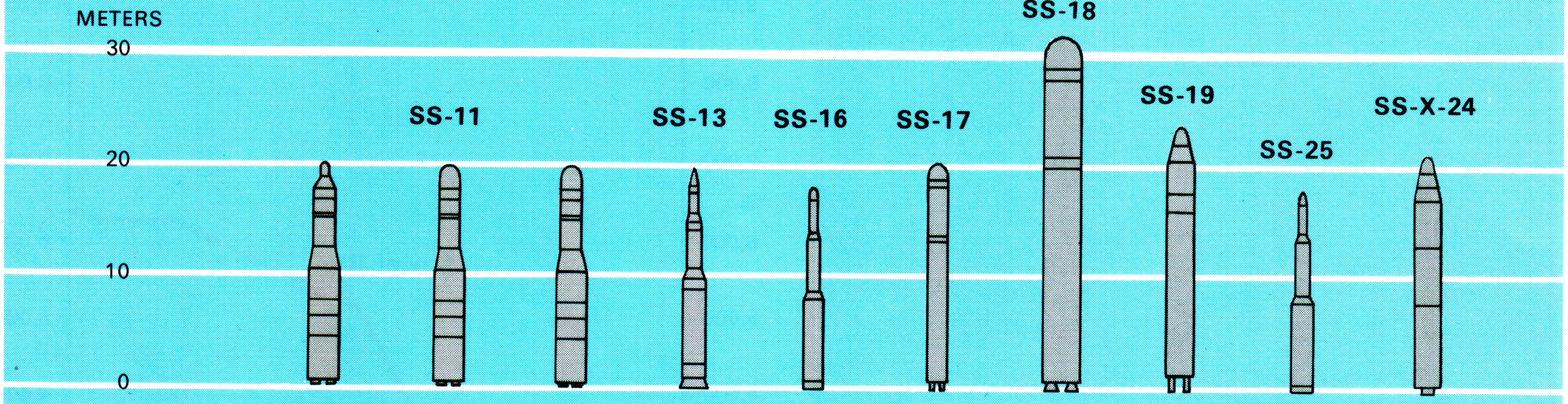


US and Soviet Intercontinental-Capable Bombers[1]



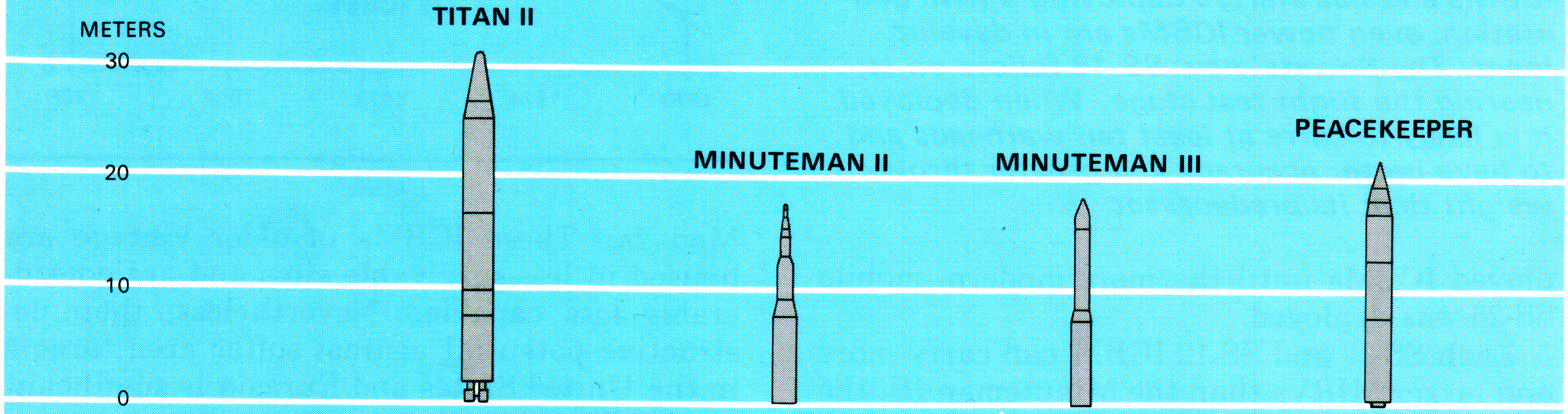
[1] US forces include B-52, FB-111, and B-1B; Soviet forces include BEAR, BISON, and BACKFIRE.

USSR ICBMs



	SS-11 MOD 1	SS-11 MOD 2	SS-11 MOD 3	SS-13 MOD 2	SS-16	SS-17 MOD 3	SS-18 MOD 4	SS-19 MOD 3	SS-25	SS-X-24
NUMBER DEPLOYED	28	420		60	Undetermined	150	308	360	70+	In Development/ Testing
WARHEADS	1	1	3 MRVs	1	1	4 MIRVs	10+MIRVs	6 MIRVs	1	Up to 10 MIRVs
MAX RANGE (KM)	11,000	13,000	10,600	9,400	9,000	10,000	11,000	10,000	10,500	10,000
LAUNCH MODE	Hot	Hot	Hot	Hot	Cold	Cold	Cold	Hot	Cold	Cold

US ICBMs



	TITAN II	MINUTEMAN II	MINUTEMAN III	PEACEKEEPER
NUMBER DEPLOYED	17*	450	550	In Development
WARHEADS	1	1	3	Up to 10
MAX RANGE (KM)	12,000	12,500	11,000+	11,000+
LAUNCH MODE	Hot	Hot	Hot	Cold

* As of early 1986